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THE EAR:

ITS ANATOMY, PHYSIOLOGY, AND DISEASES.

A PRACTICAL TREATISE

FOR THE USE OF

MEDICAL STUDENTS AND PRACTITIONERS.

BY

CHARLES H. BURNETT, A.M., M.D.,
PROFESSOR OF OTOLOGY IN THE PHILADELPHIA POLYCLINIC AND COLLEGE FOR GRADUATES IN
MEDICINE; CONSULTING AURIST TO THE PENNSYLVANIA INSTITUTION FOR THE
DEAF AND DUMB; AURAL SURGEON TO THE PRESBYTERIAN
HOSPITAL, PHILADELPHIA; PRESIDENT OF THE
AMERICAN OTOLOGICAL SOCIETY.

WITH ONE HUNDRED AND SEVEN ILLUSTRATIONS.

SECOND EDITION, REVISED AND REWRITTEN.

PHILADELPHIA:
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PREFACE TO THE SECOND EDITION.

In the seven years which have elapsed since the publication of the first edition of this work the advances in the science of Otology have been very rapid and of an eminently practical character, so that in revising this second edition the Author found many alterations necessary, while other portions of the book required to be entirely rewritten, among which may be enumerated: The Abnormalities of the Auricle, Otomycosis, The Treatment of Chronic Otorrhœa, The Classification and Treatment of Aural Polypi, and the Diagnosis, Etiology, and Treatment of Aural Vertigo. Such material as has become obsolete is of course omitted, by which, and a new typographical arrangement, the numerous additions have been accommodated without increasing the bulk of the volume.

In conclusion, the author takes pleasure in acknowledging his indebtedness to his *confrères* in this branch of medical science, both at home and abroad; their enthusiastic and meritorious labors have enabled him to make his book, he trusts, more than ever worthy the kind reception accorded to the first edition.

CHARLES H. BURNETT.

No. 127 South Eighteenth Street,
Philadelphia, August, 1884.

32083

PREFACE TO THE FIRST EDITION.

IN view of the great advances which have been made of late years in Otology, and of the increasing interest manifested in it, the Author has felt that the profession might welcome a new work, which should present clearly but concisely its present aspect, and should indicate the direction in which further researches can be most profitably carried on.

Such a work it has been the Author's aim to produce, and in accomplishing the task it will be seen that he has freely availed himself of the observations and discoveries of others. These he has, as far as practicable, tested by his own experience in the opportunities afforded by several years' special devotion to the study of the diseases of the ear.

Considerable practice in teaching has shown him that the pathology and therapeutics of the ear cannot be properly understood without a more intimate acquaintance with its anatomy and physiology than is afforded by the ordinary text-books. In these departments much important work has recently been done abroad, especially in Germany, and the author is confident that the space which he has devoted to their consideration will not be considered as excessive.

In conclusion, he trusts that, although the work is primarily designed for the student and general practitioner, it will not be found devoid of interest for the specialist.

CHARLES H. BURNETT.

No. 127 South Eighteenth Street,
Philadelphia, September, 1877.

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PART I.

ANATOMY AND PHYSIOLOGY.

SECTION I.

EXTERNAL EAR.

CHAPTER I.

THE AURICLE.

ANATOMY.

The external ear comprises the auricle and the external auditory canal. The auricle, or ear of common language, is formed of a cartilaginous sheet, from one to two millimetres thick, with various depressions and elevations. Extrinsic and intrinsic ligaments and muscles are inserted into it; it is well supplied with bloodvessels, lymphatics, and nerves, and it is covered with skin.

The auricle has no connection in its development with the branchial clefts,[1] but is an entirely independent formation from a little ridge of skin like that which forms the eyelid; the otic vesicle does not reach the surface, but an involution extends from the little prominence, which is to form the outer ear, towards the site of the otic vesicle; this is the meatus externus. (Moldenhauer.)

All the important parts of the auricle were found by Löwe in a human embryo, only one centimetre in length, showing that this part of the body is formed before the upper and lower extremities, since in the case examined there were as yet no signs of separation or differentiation into these parts.[2]

The auricular cartilage is of the reticular variety, and the various depressions and elevations into which it is twisted have received the following names: helix, antihelix, fossa of the helix, fossa of the antihelix, the tragus, the antitragus, the lobule, and the concha. The entire auricle is also called the pinna. These portions of the auricle have received other names from some authors, but those given here are, perhaps, the most commonly used in English. Henle and others give to the fossa helicis the name of fossa navicularis or scapha, and to the fossa antihelicis the name of fossa triangularis. I prefer, however, the names suggested by Gray, because they will naturally occur to any one acquainted with the anatomy of the auricle, and the combination of a few words will supply the terms necessary in the designation of the various parts of the pinna.

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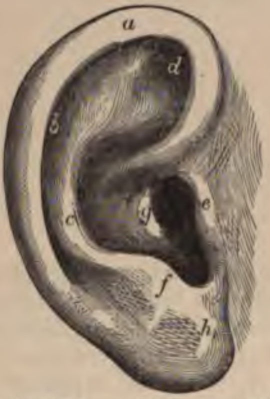
[1] Some recent opinions concerning the development of the external ear passages. David Hunt, American Journal of Otology, vol. i., 1879, p. 252.

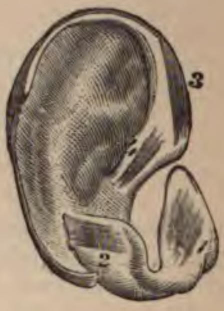
[2] Archiv f. Ohrenheilkunde, vol. xiii. p. 167.

Fig. 1.



THE AURICLE.—*a.* Helix. *c.* Antihelix. *b.* Fossa of the helix. *d.* Fossa of the antihelix. *e.* Tragus. *f.* Antitragus. *h.* Lobule. *g.* Concha.

Fig. 2.



MUSCLES ON THE OUTER SURFACE OF THE CARTILAGE OF THE AURICLE. (Ellis.)—1. Muscle of the tragus. 2. Muscles of the antitragus. 3. Large muscle of the helix. 4. Small muscle of the helix.

Muscles of the Auricle.—The extrinsic muscles of the auricle are those which move it as a whole, and are the Attollens aurem, Attrahens aurem, and Retrahens aurem.

The intrinsic muscles of the auricle, or "proper muscles of the ear," are seven in number. These have also been denominated *vestigia*, a name well chosen as indicative of their condition in man.

These muscles, with one exception, run between the various portions of the auricular cartilage and the external auditory canal. They are all muscles of animal life; but on account of their extreme thinness are pale, and lie immediately upon the cartilage, into the fibrous layer of which they are inserted by means of short tendinous fibres. They are not equally persistent; whether they are all equally developed at first and finally become atrophied through disease, can only be decided by a statistical comparison of the ears of adults and children.[1]

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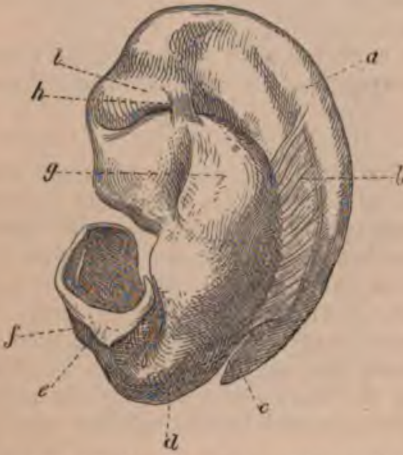
[1] Henle, Eingeweidelehre, S. 726.

Five of the proper muscles are on the anterior surface and two are on the posterior surface of the auricle. Those on the anterior surface of the auricle are the *tragicus*, the *antitragicus*, *helicis major*, *helicis minor*, and the two on the posterior surface are the *transversus auriculæ* and the *obliquus auriculæ*.

Fig. 3.



Cartilage and Muscles of the Auricle, Posterior View. (Henle.)—*f*. Cartilage of external auditory canal. *e*. Surface of attachment of same to the edge of the bony canal. *d*. Cartilage of the pinna. *c*. Cauda helicis. *l*. Eminentia scaphæ. *g*. Eminentia fossæ conchæ. *h*. Transverse muscle of the auricle. *b*. Oblique muscle of the auricle.

In some rare cases, a third muscle is found in the auditory canal, and is called the *M. incisuræ Santorini.* It lies below, and further in the auditory canal than, the M. tragicus.

Ligaments of the Auricle.—The ligaments of the auricle may also be divided into an extrinsic and intrinsic set: The first connect the auricle with the side of the head, and the second connect the various parts of the cartilage together. The former, the most important, are two in number, anterior and posterior. The anterior ligament extends from the process of the helix to the root of the zygoma. The posterior ligament passes from the posterior surface of the concha to the outer surface of the mastoid process of the temporal bone. A few fibres connect the tragus to the root of the zygoma.

Those connecting the various parts of the cartilage together are also two in number. Of these, one is a strong fibrous band, stretching across from the tragus to the commencement of the helix, completing the meatus in front, and partly encircling the boundary of the concha; the other extends between the concha and the processus caudatus.[1]

Bloodvessels and Lymphatics of the Auricle.—The arteries supplying the auricle are, the *posterior auricular*, from the external carotid; the *anterior auricular*, from the temporal; and the *auricular branch*, from the occipital. The veins follow the arteries in their general distribution.

The auricle is supplied with a beautiful and very rich network of capillary lymphatics, an important consideration in aural disease.

Nerves of the Auricle.—The nerves are most numerous on the posterior surface of the auricle, while the concave surface and the lobule are comparatively poorly supplied with nerves.

In some of the lower animals, the mole variety especially, the nervous supply of the auricle is so rich and so peculiar in its development, as to endow the auricle with valuable tactile powers.[2] The nerves of the auricle are derived from the *auricularis magnus*, from the cervical plexus; *the posterior auricular*, from the facial; the *auricular branch of the pneumogastric;* and the *auriculo-temporal* branch of the inferior maxillary nerve.

Integument of the Auricle.—The cutis of the auricle is a continuation of that of the face and head, which, after covering the cartilage, forms a fold at its base, called the lobule.

In some rare instances the cartilage of the auricle may extend into the lobule, and then the usually harmless operation of piercing it for purposes of adornment may give rise to serious chondritis.

The auricle is abundantly supplied with sebaceous glands from 0.5 to 2.0 mm. in diameter, which are most numerous and highly developed in the concha. The entire surface of the pinna or auricle is covered with downy hairs, which attain their most luxuriant growth near the meatus and on the tragus, to which fact the latter spot owes its name of "goat" or tragus. Sometimes the antitragus and even the lower part of the helix may be copiously supplied with hair, as in Fig. 4, the auricle of a man fifty years old.

Sudoriferous Glands.—The sudoriferous glands are most abundant on the posterior surface of the auricle, an important consideration in the management of the ears of infants, for if their auricles are pressed constantly against the head, as is too apt to be the case, chafing of these parts must be the inevitable result.

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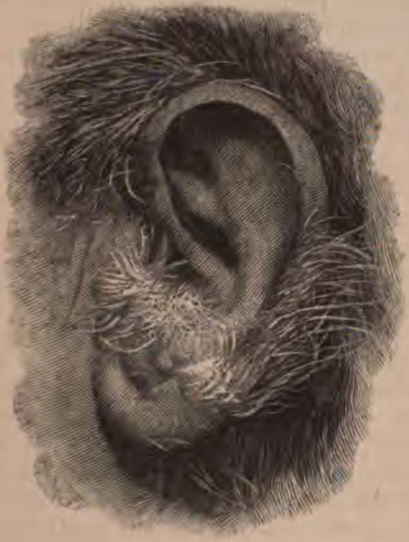
[1] Gray's Anatomy, p. 629.

[2] Max Schultze's Archiv, 1870.

Fig. 4.



The modified sudoriferous glands of the cutis of the external ear are developed into ceruminous glands in the external auditory meatus.[1]

PHYSIOLOGY.

The use of the extrinsic auricular muscles is usually very imperfectly developed in man, although the ability to move the auricle is now and then met with even in the most cultivated. It has, however, been supposed, that as civilization has elevated man above a merely animal existence, the power to move the auricle freely and voluntarily, has diminished since the necessity of such a function would cease with a less savage life.

Such indeed seems to be the rational view to take of the use of these muscles. That they are capable, however, of cultivation does not seem to be an uncommon observation. All are familiar with the story of Albinus, the anatomist of the eighteenth century, who could move his auricles so well, that he was in the habit of removing his wig in order to demonstrate to his class the power he possessed over his ears.

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[1] Kessel, Stricker's Handbuch, p. 841.

Sir Astley Cooper has recorded a case[1] in which the auricles were in constant motion whenever great attention was necessary. Two physicians of my acquaintance can move the auricles markedly with ease. I have very often seen the auricles move unconsciously in my patients, when standing behind them, and they were obliged to be more than usually attentive. But this motion was not continual; it appeared to me to be an entirely involuntary endeavor to adjust the auricle in the most advantageous position for hearing. When suddenly surprised by an unusual or loud noise, I am sensible of a very marked movement, entirely involuntary, of my own auricles.

I have seen marked contraction in the region of the tragicus and antitragicus muscles, during the application of the constant electric current by means of a ball-electrode.

The power to move the auricle is not dependent, apparently, alone upon the illy developed muscles of the ear, as has been pointed out by Samuel Sexton,[2] of New York. According to this observer, the *attollens aurem* and *attrahens aurem* are aided in this performance by the *orbicularis oris* and the *occipito-frontalis* muscles. These last-named muscles are said to be able, by conjoint action, to make tense the fascia in front of and just above the tragus, and when this same force is exerted upon that portion of the deep temporal fascia extending along the anterior margin of the osseous meatus until lost in the anterior ligament of the auricle, the drum-head itself would be made more tense, especially the more distensible portion, known as the membrana flaccida, which is in reality a continuation of the skin of the external auditory canal.

Dr. Sexton, aided by Dr. S. H. Pinkerton, made a dissection of an ear in a recent subject, in order to determine the extent of "the motion thus transmissible through the deep temporal fascia to the motor (drum-head) of the transmitting mechanism of the ear. First, the deep temporal fascia was dissected up to where it is blended with the anterior ligament of the auricle. At this stage of the proceeding it was found that traction on the deep temporal fascia moved the auricle freely. The anterior attachment of the auricle was then divided, and a section of the petrous bone was made by sawing down through the tympanum from above, separating the incus from the stapes and bisecting the tensor-tympani muscle in its bony canal, leaving the rest of the mechanism of the middle ear intact, with the exception of a slight laceration of the drum-head at its inferior segment. It was now found that if that portion of the tensor tympani left attached to the manubrium mallei was made taut and so retained in the grasp of forceps while traction was made as before on the temporal fascia, which had been dissected up, the transmitting mechanism responded promptly and became more tense than before. When alternate tension and relaxation were practised on the fascia, the drum-head tightened and relaxed likewise, the motion being perceptible to the eye. These apparently demonstrable influences of muscular action in the middle ear mechanism in man, are similar to those which in a more perfect manner are obtained in the horse, dog, and other animals by means of the voluntary action of their more efficient muscles."

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[1] Phil. Trans., London, 1800.

[2] New York Medical Record, Nov. 17, 1883, p. 543.

The general opinion is that a small ear, well shaped, is a sign of careful breeding, whereas the large elephantine auricle is accepted as a type of vulgarity;[1] however, the unfortunate possessor of a large auricle is compensated for his so-called misfortune, by the popular belief that the large auricle is a sign of good nature and generosity. This may be the modern idea, but Giotto, in his drawing of Envy, in the chapel of the Arena at Padua, represents the auricle as superhuman in size, its long axis as a continuation of that of the horizontal ramus of the inferior maxillary bone, and without a lobule.

It is also a matter of interest that the position and shape of the auricle are race-peculiarities. In the Egyptians they are placed high on the side of the head, as may be seen in the present day, and also in the rude attempts at artistic portrayal in their very ancient monuments and statues.

Prof. Meyer[2] states that it has already been noted by previous observers that malformations of the external ear are found in the greatest number in connection with arrested development in the region of the first (Kiemenspalte) branchial or visceral fissure, viz., with cleft palate, and other forms of retarded development in the bones of the head and face. The explanation of Virchow, that these changes are due to inflammatory processes in the earlier days of fœtal development, seemed sufficient to Meyer, until, as he says, he instituted a careful examination of the form and position of the external ear, in a number of insane people, manifesting those pecularities described and called by him cranium progenicum. In all these cases there was a relative arrest of development of the bones of the face, especially a malformation of the inferior maxilla, and it should be borne in mind that the inferior maxilla is formed through ossification in the membrane of the visceral arch. The expectation of finding, in just such cases, characteristic forms of the ear, was not realized, and the theory appeared the less tenable the further the investigation was extended to numerous cases of both the insane and the sane. Pathologically, the result of the investigation is considered by Meyer to be unimportant, and he expresses a belief that the significance of the form and position of the external ear is purely of a physiognomical character.

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[1] Parvæ malos mores docent, magnæ et erectæ indices sunt stultitiæ aut loquacitatis. Opera Galeni, iv. 797. Kühn, Leipsic, 1833.

[2] Ludwig Meyer, Ueber das Darwinische Spitzohr. Virchow's Archiv, Band 53, Heft 4.

In connection with a beautiful, well-formed face, we usually find a round, well-formed, small and close-lying ear; whereas, in macrocephalic heads we find large, massive, in some cases real elephantine ears; while the narrow ear directed backward, the so-called Faun's ear, accompanies a low, retreating forehead, sharp nose, and narrow chin. A comparative examination of normal male heads seems to indicate that the position of the ear possesses a certain and constant relation to the architecture of the skull, for female heads, with a large facial angle, show a more vertical position of the auricle than is usually seen in females and in children, who possess, as a rule, small facial angles.

In women and children we often find, in connection with a large facial angle, obliquely placed ears, so that the upper part of the helix points backward, and the posterior portion is directed downwards. The cause of this is to be sought for in the relation of the ramus to the body of the inferior maxilla rather than in the relations of the superior maxilla and the frontal bones to one another. The explanation of the connection between the position of the ramus of the inferior maxilla and the external ears is to be referred to the development of those portions of the face from the same part of the branchial arch. Not only the position of the ears, but the elevations and depressions of the auricle vary even in the same individual.

Mr. Darwin's ideas of the significance of certain prominences in the helix are thus given by that distinguished observer: "The celebrated Mr. Woolner informs me of one little peculiarity in the external ear (*i. e.*, auricle) which he has often observed both in men and women, and of which he perceived the full signification. His attention was first called to the subject while at work on his figure of Puck, to which he has given pointed ears. He was thus led to examine the ears of monkeys, and subsequently, more carefully, those of man. The peculiarity consists in a little blunt point, projecting from the inwardly folded margin, or helix. . . . . These points not only project inward, but often a little outward, so that they are visible when the head is viewed from directly in front or behind. They are variable in size and somewhat in position, standing either a little higher or a little lower; and they sometimes occur in one ear and not in the other. Now, the meaning of these projections is not, I think, doubtful; but it may be thought that they offer too trifling a character to be worth notice. This thought, however, is as false as it is natural. Every character, however slight, must be the result of some definite cause, and if it occurs in many individuals, deserves consideration. The helix obviously consists of the extreme margin of the ear folded inward, and this folding appears to be in some manner connected with the whole external ear being permanently pressed backward. In many monkeys which do not stand high in the order, as baboons and some species of maccaus,[1] the upper portion of the ear is slightly pointed, and the margin is not all folded inward; but if the margin were to be thus folded, a slight point would necessarily project inward and probably a little outward. This could actually be observed in a specimen of the *Ateles beelzebuth* in the Zoölogical Gardens; and we may safely conclude that it is a similar structure—a vestige of formerly pointed ears—which occasionally reappears in man."[2]

Prof. Ludwig Meyer,[3] in an article referring especially to Darwin's idea, that the common, small projections in the helix of the ear are remnants of the pointed ear of certain Simian races, says that too much importance has been attached to the deviations in the form of the auricle, but he admits that frequently we find irregularities in the edge of the helix. To one of these, more prominent than the others, Darwin has attached the significance already alluded to. Now, the edge of the helix is rarely completely smooth, and even when any slight inequality of the helix escapes the eye, the finger can readily detect it. These are really deficiencies and not absolute prominences, and the wider the loss of substance in the helix-cartilage, the more prominent will the remaining portions appear.

If, in an ear where one or two such prominent remnants of the helix occur, a line be drawn joining them, it will correspond with the outline of the normal helix. That these prominences are nothing more than remnants of the helix, is proven by the fact that their inclination and curve correspond entirely with the curve of the helix.

That part of the helix which affords the most examples of the peculiarity referred to by Darwin, is best adapted to producing the longest points, since it is the widest portion of the curved helix. These changes in the ear are doubtless not produced during life, but are congenital. They are found in perfection in little children, and are more apt to occur in males than in females. According to Kollman, the helix is not a separate point of development. The auricle consists originally of those formative parts which can be distinctly recognized at the end of the sixth week of fœtal life, as tragus, antitragus, and antihelix. From the latter the helix is developed. Hence we see that as interferences in the development of the tragus may cause the presence of a cleft in it, so may disturbances in the development of the antihelix cause deficiencies in the helix.

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[1] See also some remarks and the drawings of the ears of the Lemuroidea in Messrs. Muril's and Mivart's excellent paper in Transact. Zoöl. Soc., vol. vii. pp. 6 and 90, 1869.

[2] Darwin, Descent of Man, vol. i. pp. 21 and 22.

[3] Ludwig Meyer, Ueber das Darwinische Spitzohr. Virchow's Archiv, Band 53, Heft 4.

Laycock[1] observes that men of high intellectual attainments, great capacity for mental labor, and great force of character, have a full, perfectly ovoid ear, the helix well developed, the lobule plump, pendent, and unattached to the cheek at its anterior margin. These characteristics are seen in all portraits of great men which Lavater gives, and are easily observed in living celebrities.

The same writer also says: "In a perfect ear the ovoid lobule hangs from the cartilage with a rounded lower margin, which, at its inner border, is not confluent with the face. Now, if this inner margin be adherent to the cheek, and at the same time the lobule be only a segment of an ellipse, there is more or less tendency to imperfect cerebral action. A more important form is seen when the lobe is not only soldered to the cheek, but its posterior half cut away, as it were, and the helix defective."

A knowledge of these peculiarities in the ear of an individual may become of great legal value, as in the Tichborne case, in which it was shown that the "claimant's" ears were altogether different from those of the lost heir.

Comparative Functions of the Auricle.—The functions of the auricle are modified by the habits of the animal, and, since in most four-footed mammals the external ear is well developed, we have an opportunity of observing in them a variety of functions, acoustic and other, acquired by the auricle. The large, long, and easily moved auricles are found in animals that are timid and often pursued by stronger and sagacious animals, while those which pursue, as lions, tigers, etc., possess auricles which are short and directed forwards.

We have no positive means of finding out how sounds are modified by these peculiarities in the auricles of these animals. However, by applying a variety of speaking-trumpets to our ears, and by alterations in the position of these artificial auricles, as well as of our own by manipulation, we may form, at least, an approximate idea of the modification in hearing produced by the size, shape, and position of the auricle. By such experiments we see that it is highly probable that ordinary sounds are augmented, and faint sounds rendered very audible to animals with largely developed auricles, by the increased resonance such organs produce, a function of the auricle useful to animals which are rapacious as well as to timid ones which are pursued.

---

[1] London Medical Times and Gazette, March 22, 1862.

The auricle is small in seals, walruses, moles, and the manis, but largely developed in some species of the bat, and "is so constructed as to prevent air from rushing in while flying."[1]

In birds, the auricle is wanting, as it would probably greatly impede their flight, but in night birds, the power to elevate the feathers around the ear seems to indicate that they can supply themselves at will with a kind of auricle, and that their hearing is thereby augmented, a necessity due to their nocturnal pursuits.

The auricles of the mouse[2] and of the hedgehog[3] are developed into organs of touch, and the auricles of marine mammals seem to become almost useless; as in the narwhal "the opening of the ear is of the diameter of a knitting-needle,[4] and in the leopard seal the ears are merely openings in the surface of the skin, which are placed an inch and a half behind the eye,"[5] while in the sea-otter[6] the "ears are less than an inch in length," the animal being at least five feet long.

In the water-shrew, an aquatic mammal, the antitragus serves as an operculum to the auricle, which fact seems to indicate that the auricle is no longer needed for hearing as soon as the animal ceases to live in the air. In the crocodile, also, the auricle acts as an operculum, and in the whale it is practically absent. Therefore, the fully developed auricle is needed by and found in mammals whose life and condition are aërial, and we find that it ceases to exist, or its functions are altered, in mammals inhabiting the water or living underground.

The auricle of the *Blarina brevicauda*, a water-shrew, is a remarkably complicated structure.[7] It is valvular in its function, so as to keep water from entering the external auditory canal. The auricle in this animal is folded forward, there is no lobule, hair grows on the back surface, which in the peculiar development becomes the outer surface, and fits so closely over the meatus as to look as though the animal had no external ear, and has given rise to the name of "anotus" or "cryptotus," as applicable to this creature.

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[1] J. Williams, Treatise on the Ear, London, 1840, p. 35.

[2] J. Schöbl, Max Schultze's Archiv f. Mic. Anat., 1871, p. 260, four plates.

[3] Ibid., 1872, p. 295.

[4] Marine Mammalia of North America, by Chas. M. Scammon, U. S. Rev. Marine, p. 108.

[5] Ibid., p. 165.

[6] Ibid., p. 168.

[7] Outer Ear of Blarina Brevicauda, Dr. Elliott Coues, U. S. A., American Journal of Otology, vol. i., 1879, p. 161.

Resonant Functions of the Human Auricle.—As early as 1840, J. Williams, M.D., of London, attributed to the "configuration and tension of the auricle" the function of determining the "finesse of hearing." This author was led to such a conclusion by the augmentation of sound obtained by pressing forward the auricle, and surrounding it by the hand, but he erroneously referred the improved hearing which ensued to the overcoming of what he termed a relaxed condition of the auricle by the support of the hand. It was, on the contrary, due to the augmented resonance of the auricle, brought about by the relative lengthening of the external ear, by pushing the auricle out from the head, and adding to it the resonance of the hand. It is evident, therefore, that writers on the ear long ago noted the phenomena of alteration in the resonant functions of the external auditory apparatus caused by increase or diminution of its depth and position; but that these phenomena depended upon the power of the auricle and the external auditory meatus to act as resonators was not suggested nor proven until Hemholtz's experiments in acoustics had rendered the subject of resonators clearer, and experiments on the human ear demonstrated that the most probable function of the auricle is that of a resonator, adapted to augment just those *high* notes or sounds most likely to be of interest and importance to man.

According to Dr. Küpper,[1] the auricle can reflect sound into the auditory canal only to a limited extent, "because that part of the auricle which would reflect the sound-wave falling on it, into the auditory canal, is very small." Nor does he believe that it is concerned in the direct collection and transmission of sound as the drum-head is, for it is neither so elastic as the latter, nor is it inserted into a bony frame. He also denies it the function of determining the direction of sound, which, he thinks, may be proven by inserting into the meatus, a tube of any kind, thus cutting off all participation of the auricle in the reception of sound, when it will be found that the direction of sound can still be told.

This author appears to be wrong in his assertion that the auricle can have no influence in hearing, for it is well known that with the altered shape of the auricle in othæmatoma, the hearing is altered. He furthermore argues that the auricle in man is useless, because birds have none; but birds do not need an auricle, on account of the high resonance of their auditory canal, as well as the interference in flying such an appendage would entail. Dr. Küpper, therefore, places the auricle of man in the "list of organs inherited, but no longer possessed of functions." He, however, ascribes an important part to the auricle in the lower animals, agreeing with Müller[1] that as it is supplied with so many (17) well-developed muscles, it is well adapted to catch sounds, but especially to express the passions of the animal, as is best seen in the horse. Dr. Küpper, however, apparently does not believe that the auricle of man, while losing the function so sharply seen in the lower animals, gains the higher and more delicate one, of a resonator for the nobler tones of the human voice, as shown by the author.

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[1] Archiv f. Ohrenheilkunde, vol. viii. p. 158.

Prof. E. Mach[2] considers the auricles in the lower animals, resonators for the higher tones of ordinary sounds important for them to hear, such as the rustling of grass and leaves. This function depends partly upon the ability of the animals to place the auricles towards the direction of the sound, and thus to alter the clang-tint, which leads to a proximate knowledge of the direction of the sound. A remnant of such a function may still be found in the human auricle, according to Mach, which agrees with the theories advanced, previous to those of Mach, by the author.[3]

In the summer of 1873, while I was travelling and exposed to a great variety of powerful sounds, of nature and of commerce, I made some experiments on my own external ears, respecting their power of receiving all or part of the component tones entering into such complex sounds, as the rustling of leaves, the roar of Niagara, the seething and hissing noise heard in the wake of a large steamer, or in the escape of steam from a powerful locomotive or steamboat. I found that by altering the position of my auricle, that is, by relatively lengthening thereby the depth of the external auditory canal, I could analyze the composite sounds alluded to, for if I pressed my auricle firmly back against my head, I heard the higher sounds, *i. e.*, the entire sound became to my ear apparently of a higher quality, whereas, if I pushed my auricle outward and forward, the deeper partial sounds became more pronounced, and the entire composite sound became louder and deeper.

Drs. A. H. Buck and C. J. Blake have informed me that they have corroborated in themselves my observations and statements in this connection. In the autumn of 1873 I published my first paper, and in the spring of 1874 my second paper on what I had observed respecting the function of the external ear, especially of the auricle, as a resonator for higher notes.

The first paper contained chiefly a description of the phenomena I had observed; and the second paper was devoted specially to their physical explanation.

The substance of the first paper was the following, antedating the papers of Drs. Küpper and Mach:

Before any further explanation of the functions of the auricle, let us briefly consider the acoustic nature of some of the ordinary sounds which are received by it. It is well known that every sound is composed of a collection of "partial tones" or "over-tones" which determine its timbre or clang-tint. Any one of the ordinary sounds of nature, as, for example, the roar of a cataract or of the surf, and the rustling of the leaves in a forest, is composed of a large number of partial tones, which, for the sake of simplicity, let us call deep, intermediate, and high partial tones.

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[1] Physiologie der Haussäugethiere.

[2] Archiv f. Ohrenheilkunde, Bd. ix. S. 72, 19 June, 1874.

[3] Phila. Med Times, No. 101, Oct. 4, 1873; No. 127, April 4, 1874.

The ordinary normal ear does not isolate any of the partial tones of a composite sound, but perceives them as a whole.

This is due to the fact that certain parts of the auricle resound best to the high partial tones, while other portions of it resound best to the intermediate and low partial tones, thus insuring the complete reception by the auditory nerve of all the partial tones which compose any given sound falling on the auricle. I have discovered, by experiments upon my own ear, that the region of the helix and its fossa resound to the deeper notes, the antihelix and its fossa to the intermediate notes, and that the concha, "the deep concavity within the position of the antihelix, presenting a semi-spiral course towards the entrance of the auditory meatus," resounds best to the high partial tones. In order to prove this it is necessary to be in the presence of a sound possessing the characteristics of those already mentioned, when, by pressing the auricle at its outer edge gently forward, the sound instantly becomes a deeper one, from the augmentation of the resonance for deep tones thus gained by the helix and its fossa.

The deep tones, however, are immediately weakened or lost by placing the finger upon the helix and pressing it firmly against the head. Then it is found that the sound becomes one in which the intermediate and higher partial tones are prominent. By pressure upon the antihelix the intermediate tones become weaker, and the higher partial tones are most distinctly perceived, on account of their undisturbed resonance in the concha. Firm pressure upon the helix, antihelix, and concha will interfere with the resonance of all but the highest partial tones. In the latter instance the resonance of the meatus auditorius externus has full scope, for this part of the ear, according to Helmholtz, resounds best to notes of the fourth octave (e^{iv}–g^{iv}). Therefore, if any one of these portions of the auricle has its acoustic functions altered, either by disease or artificially, the tones to which it resounds will be weakened or lost, and the prominence of the other partial tones will change the timbre of the original sound.

Experiment will show that by giving prominence to a certain portion of the auricle, viz., the helix and its fossa, a sound may be rendered fuller, and hence louder, from the increased resonance of the deeper notes which enter into its composition. This may explain the asserted increase of hearing in some cases of othæmatoma, when the swelling may have rendered these particular parts prominent, and thus have increased their resonant power. But if the disease advance and produce great swelling and rigidity of the auricle, as it usually does, we can also readily understand the impairment of hearing in these cases. One without an auricle, all the rest of the auditory apparatus being normal, can indeed hear sounds, practically very well, but they are altogether different, acoustically considered, from the complete composite sound heard by the possessor of the normal auricle. In the former case, a large number of the partial tones being lost, the clang-tint of the sound is altered; whereas in the latter case, the auricle receiving and conveying synthetically all the partial tones to the auditory nerve, the timbre of the composite sound is fully perceived.

The substance of my second paper,[1] explaining what I had observed, was as follows:

The auricle, in combination with the meatus auditorius, forms a resonator of a more or less conical shape, closed at the bottom by the membrana tympani, the special function of which is to strengthen by resonance those waves of sound which possess a short wave-length.

Let the accompanying diagram represent a section of the external ear, from the membrana tympani to the helix. The section is made from above downward, parallel to the long axis of the meatus auditorius externus, and gives an ideal representation of the manner in which the resonator we shall consider is built up by the auditory canal and the successive columns or cups of air, represented by the concha and fossæ of the helix and antihelix.

Fig. 5.

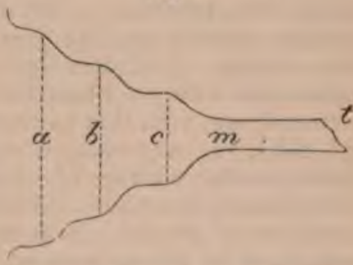

Diagram representing the Topographical relation of the component resonant cavities of the External Ear.—*a.* Fossa of helix. *b.* Fossa of antihelix. *c.* Concha. *m.* Meatus auditorius externus. *t.* Membrana tympani.

The widest diameter of this resonant cone or funnel, or miniature "speaking-trumpet," *i. e.*, the diameter obtained when the helix and lobe are made to approach each other about the opening of the external meatus as a common centre, does not exceed the wave-length of the note to which the resonator thus formed will respond. In order fully to understand how this resonant power is maintained by the external ear, and to sound-waves of what length it specially resounds, let us first consider the resonance of the meatus auditorius externus, and the physical reasons for such a function in it.

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[1] Phila. Med. Times, April 4, 1874.

It is known that the external auditory canal resounds to the notes e^{iv} to g^{iv},[1] and that the column of air which most easily resounds to any given note is equal to one-fourth of the length of the wave of sound produced by that note.[2] Now, the wave-length is found by dividing the velocity of sound per second by the number of vibrations executed by the sounding body per second,[3] and the quarter of the result of this division, *i. e.*, the quarter of the wave-length, will equal the length of the column of air which will act the part of a resonator for the note producing the sound-wave.

In order to appreciate this fact, let us work out a simple problem in physics, with the data before us, as follows: As already stated, the notes e^{iv} to g^{iv} have 2640 to 3168 vibrations per second, and the velocity of sound in atmosphere at 15° C. is equal to 1122 feet per second. Therefore, the length of the wave produced by the note of 3168 vibrations per second will be found by dividing 1122 by 3168. The answer will be, about three-eighths of a foot, or four and a half inches.

Now, the column of air which will resound to the note producing a wave of that length is equal to one-fourth of that wave-length, or one and one-eighth inch, which is just the short average length of the external auditory canal. Some authorities give one and one-fourth inch as the average length of this canal, but practically the normal human auditory canal has various lengths, passing gradually from the meatus proper into the concha. And this brings us to the second consideration connected with the phenomena of resonance manifested by the external ear, viz., that as the pitch of a note, let us say of e^{iv} or g^{iv}, falls, the wave-length must become greater, or, in other words, as the number of vibrations per second diminishes, the wave-length increases; which is but the enunciation of a common law of physics. It is now manifest that the column of air contained by the external auditory canal will not be long enough to act as a resonator for waves of sound the quarter of which is represented by one and three-fourths to two inches.

Therefore, the concha is found superposed by nature upon the external auditory canal, in order to lengthen it. We have already seen from experiments that the notes which resound to the column of air represented by the concha, *i. e.*, the concha in conjunction with the external auditory canal, are lower than those which resound to the external auditory canal when it is made to act alone, which can be accomplished by pushing the concha out of place by firm pressure of it against the head. The reason for this becomes very clear when we reflect that a note lower than those represented in the scale from e^{iv} to g^{iv} must have a greater wave-length, and therefore it requires a longer column of air as a resonator. If this lower note should fall in the octave below those notes already mentioned, the addition of the column of air in the concha to that in the meatus would supply the resonator.

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[1] Helmholtz's Tonempfindungen, p. 175, 1870.

[2] Tyndall, On Sound, p. 174, 1869.

[3] Ibid., p. 84.

If to this resonator, composed of the canal and concha, we add the fossæ of the antihelix and helix, we of course obtain longer or deeper resonant columns of air; and I know from my experiments that notes of still greater wave-lengths than those alluded to resound to the column of air represented by that contained in the fossæ of the auricle added to that of the concha and external auditory canal.

By holding the hand behind or around the ear, we have the power of adding a still deeper column of air and its resonance to that of the external ear. Hence, the deaf person involuntarily places his hand to his ear, to increase, by resonance, the ordinary sound falling upon it. His hearing is thus strengthened, especially for those notes of high pitch and short wave-length to which the human voice owes its peculiar timbre or clang-tint. When the wave-length increases, as it does when the note becomes still lower than any of those alluded to, the resonance of the external ear ceases to exert any marked influence on the fundamental note. In such a case it is probable that the resonance of the room or street in which we are placed is aroused by the longer wave of sound; but nature has supplied us, in the external ear, with an ever-present and delicate resonator for just those notes of short wave-length in which the human voice is so rich and to which it owes its special timbre.

We may, therefore, conclude that *the external ear* (*i. e.*, the external auditory canal and the auricle) *forms a resonator for those tones having wave-lengths the quarters of which are represented by the various depths of the column of air contained by the external ear.*

From what has just been shown respecting the resonant functions of parts and of the whole of the auricle and external auditory canal in man, it seems fair to suppose that the entire apparatus of the external ear in all animals is adapted to strengthening the sounds uttered by them, their species, and their prey. The absence of a developed auricle in birds is not, in my opinion, an argument against its utility as a resonator in man, for the wave-lengths of the high notes which the former must both use and hear as a means of intercourse with one another, are so short that they will resound perfectly well in the shallow auditory meatus found in them.

The auricle is supposed by Kessel[1] to possess the function of aiding in the determination of the direction of sound, and he attributes to this part of the ear, as I have, the power of analyzing sound.

Temperature of the External Auditory Canal.—Dr. E. Mendel,[2] of the University of Berlin, has performed a series of experiments to find the relative differences between the temperature of the rectum and that of the external ear under physiological and pathological conditions of the general system.

In the normal condition, the temperature of the rectum is 0.02° C. higher than that of the external auditory canal.

Further experiments in cases of apoplectiform and epileptiform paralysis show that in such pathological states the temperature is higher than that in the rectum.

Sleep-producing doses of chloral do not materially alter the temperature of the rectum, but they reduce considerably the temperature of the external auditory canal. The amount of this depression in the ear varies from 0.04°–1° C. It sets in in from ten minutes to half an hour after the chloral is given, and lasts until sleep is ended.

Morphia has also a specific effect in reducing the temperature of the external auditory canal in varying amounts, from 0.1°–0.45° C.

This I consider important for aurists to know, inasmuch as further experiments of Mendel[3] show that even ice-bags fail to reduce the temperature of the external auditory canal as chloral and morphia do.

[1] Archiv f. Ohrenheilkunde, vol. xviii., 1882, pp. 120–129.

[2] Virchow's Archiv, 62 Band, 1874.

[3] Loc. cit., p. 141.

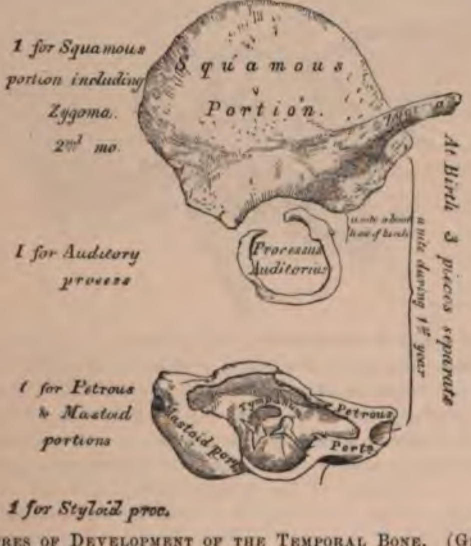
CHAPTER II.

THE AUDITORY CANAL.

ANATOMY.

The Temporal or Petrous Bone.—Before considering the anatomy and physiology of the external auditory canal, it will be necessary to examine into the development and anatomy of the temporal or petrous bone. The outer surface of the temporal bone represents the convex curve of a low arch, the spring line of which runs through the outer part of the middle lobe of the brain. The squamous portion, which is the larger part of this surface, being thin, and the arch it spans low, the temporal bone would be very weak in resisting external forces, were it not for the support placed on its inner surface by the petrous portion.

Fig. 6.



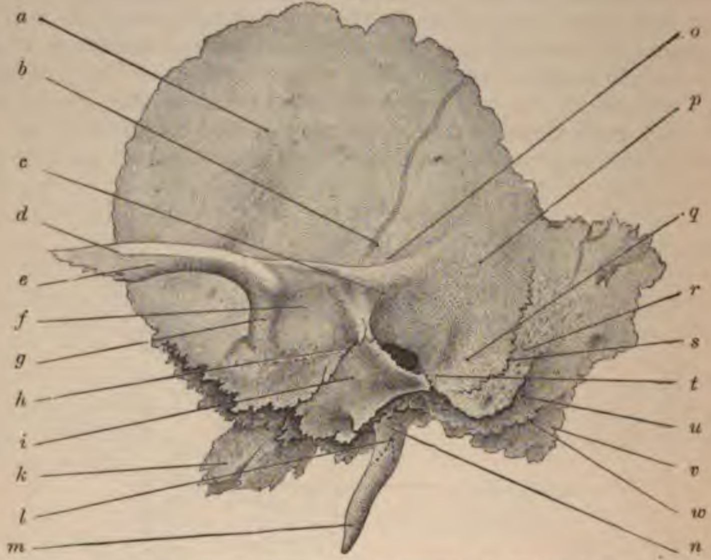
Centres of Development of the Temporal Bone. (Gray.)

Embryology of the External, and Parts of the Middle Ear.—The Eustachian tube is an involution of the pharyngeal mucous membrane, and is not the remains of a branchial cleft. (D. Hunt.)

The external auditory canal is an involution of the integument, formed as a burrow in the tissue which composes the first branchial arch. The membrana tympani is formed by the junction and overlapping of the ends of the Eustachian tube and external auditory canal, the connective-tissue layer between them forming the membrana propria of the membrana tympani.[1]

The temporal bone develops from four distinct centres, exclusive of those representing the internal ear and the auditory ossicles.

Fig. 7.



Left Temporal Bone: Outer Surface.—*a.* Squama. *b.* Groove for temporal artery. *c.* External auditory meatus. *d.* Zygomatic process. *e.* Insertion of masseter muscle. *f.* Glenoid fossa. *g.* Articular ridge. *h.* Glaserian fissure. *i.* Tympanic bone: anterior wall of external auditory canal. *k.* Inner end of petrous or pyramidal portion of temporal bone. *l.* Insertion of styloglossus muscle. *m.* Styloid process. *n.* Insertion of stylohyoideus muscle. *o.* Insertion of temporal muscle. *p, q.* Mastoid portion. *t.* Mastoid process. *r.* Insertion of sterno-cleido-mastoid muscle. *s.* Squamo-mastoid fissure. *u.* Mastoid incisure. *w.* Insertion of splenius capitis muscle. *v.* Insertion of trachelo-mastoid muscle.

These are: one for the squamous portion and the zygoma; one for the auditory process, or annulus tympanicus, which finally becomes the tympanic bone, and forms the anterior, inferior, and superior part of the osseous auditory canal; another for the petrous and mastoid portions, and a separate point of development for the styloid process.

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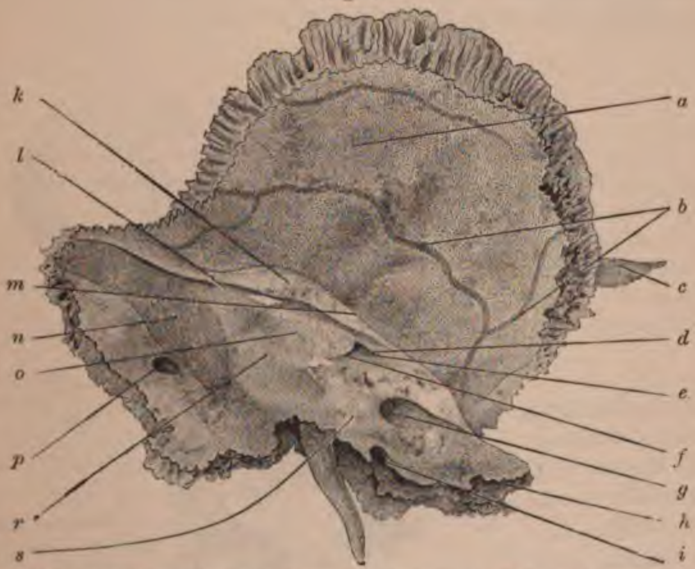
[1] Von Baer, Huschke, and Köllicker among older writers; among recent writers, D. Hunt, International Otolog. Congress, 1876, and American Journal of Otology, vol. i., 1879, p. 250; Moldenhauer, Morphologisches Jahrbuch, 3tes Bd., 1stes Heft; Urbantschitsch, review in Archiv f. Ohrenh., 12tes Bd., iv. Heft, S. 293.

It appears from the anatomical investigations of Adam Politzer[1] that the styloid process, the variable form of which is well known, originates from an individual cartilage-centre, which, not only in fœtal life, but also in the new-born child, is demonstrable as a separate cartilaginous body, and that the upper end of the styloid process is not found at the externally visible base of the process, but that it extends upward as far as the lower part of the eminentia stapedii, along the posterior limit of the tympanic cavity, from which it is separated by a thin osseous lamella.

Fig. 8.



LEFT TEMPORAL BONE: INNER SURFACE.—*a*. Squama. *b*. Meningeal groove. *c*. Zygomatic process. *d*. Semicanal of Vidian nerve. *e*. Hiatus of Fallopian canal. *f*. Canaliculis petrosus empties into this groove. *g*. Porus acusticus for auditory nerve. *h*. Carotid canal. *i*. Jugular notch. *r*, *o*. Petrous or pyramidal part of bone. *p*. Mastoid foramen, for vein. *n*. Sigmoid groove for lateral sinus. *l*. Groove for superior petrosal sinus. *k*. Eminence of superior semicircular canal. *m*. Petroso-squamous suture. *s*. Aquæductus vestibuli.

The Developed Temporal Bone.—Space forbids a lengthy consideration of the developed temporal bone, but a few prominent features deserve notice here, as, that under the floor of the tympanic cavity is part of the jugular fossa; that the anterior wall is part of the carotid canal; that the roof of the tympanic cavity is a thin bony septum between the brain and the middle ear; and that the mastoid cells are separated by a thin partition of bone from the sigmoid fossa, in which runs the lateral or transverse sinus of the dura mater. In addition to these facts, may be mentioned that the entire internal ear, or labyrinth, lies in the petrous pyramid of the temporal bone, that the middle ear is formed by the union of the squamous, petrous, and mastoid portions of the temporal bone, and that the osseous portion of the Eustachian tube lies in the inner end of the petrous portion of the temporal bone, through which the tensor tympani muscle may be said to run on its way to the tympanum. A more detailed explanation of this muscle will be given when

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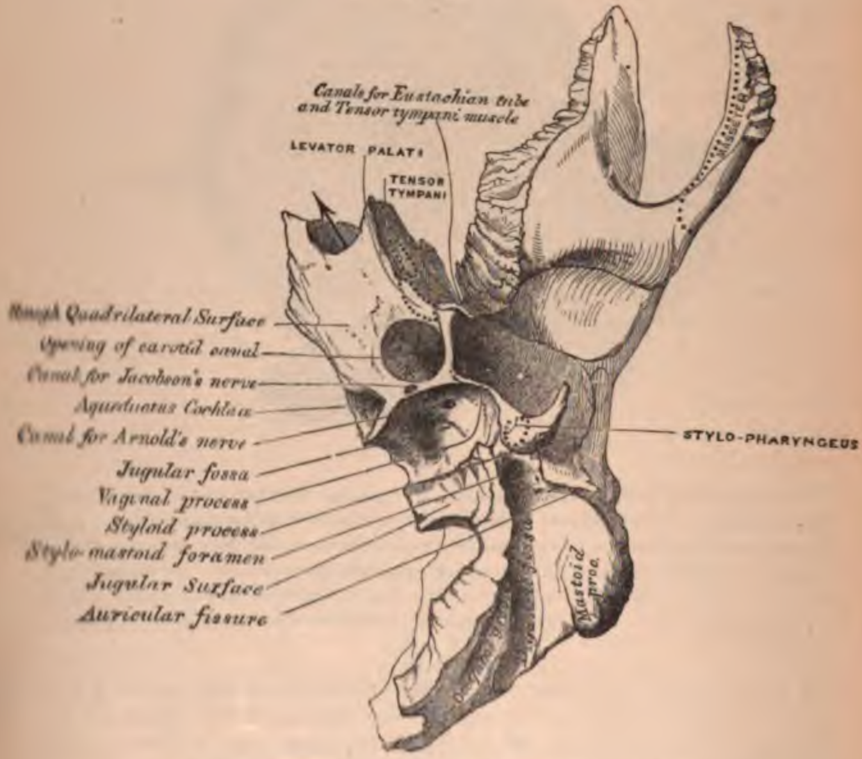
[1] Archiv f. Ohrenheilkunde, Bd. ix. S. 164.

Fig. 9.



UNDER SURFACE OF LEFT TEMPORAL BONE. (Gray.)

alluding to the soft parts of the Eustachian tube. Furthermore, the levator palati, an important tubal muscle, originates at the under surface of the temporal bone, near the inner end of the petrous part; the carotid canal passes through this part of the bone, and the jugular fossa is partly formed by the temporal bone; the facial nerve passes through this bone from the brain to the face, and the aquæductus cochleæ, the important exit for the perilymph of the labyrinth, is placed near the carotid canal on the under surface of the temporal bone. It is also important for the aurist to bear in mind that on the upper and cerebral surface of the petrous portion are the petrosal sinuses, and that these are closely connected with the cavernous sinus, which, in turn, is emptied into by the ophthalmic vein, a relationship which may often explain facial and ocular symptoms in obstruction of the sinuses from aural disease.

The small opening of the aquæductus vestibuli, on the posterior surface of the pyramidal petrous part of the temporal bone, near the entrance of the auditory nerve, must not be forgotten, as at this point purulent disease may often be found to have entered the cranial cavity from the tympanum and vestibule.

The anterior wall of the external bony auditory canal forms part of the glenoid fossa, and it can thus be seen how, in certain inflammations about the ear, movements of the jaw are exceedingly painful.

At birth the bony auditory canal does not exist; the ring from which it is developed is deficient at the upper fourth, and the canal is represented at that point by the curved lower edge of the squama. The aforesaid ring grows at last into a tube which forms the posterior, inferior, and anterior wall of the osseous external auditory canal, to which the name of tympanic bone is also given. In the new-born child the mastoid portion is also rudimentary and not fully united with the squama. At the line of imperfect union between these two parts of the temporal bone, quite large deficiencies are found in early childhood and in some cases persist even into adult life.

Development of the Bony Auditory Canal.—The osseous auditory canal, *i. e.*, the inner and major portion of the entire auditory passage, is developed from the so-called drum ring, *annulus tympanicus* or processus auditorius. This ring, which is open or interrupted (for 1–2 mm.) at a point in its postero-superior periphery, has a furrow on its inner edge called the sulcus tympanicus. This ring, united to the squamous and petrous portions of the temporal bone, gradually grows outward, and forms the antero-superior, anterior, and antero-inferior wall of the bony auditory canal.

The two prominent points (see Fig. 6) on the anterior and upper part of the ring are called by Henle *spina tympanica antica* and *postica*, and are the terminal points of a ridge forming the upper boundary of a furrow called the *sulcus malleolaris*, which finally becomes the posterior boundary of the *petrotympanic* or *Glaserian fissure* for the reception of the long process, processus folianus of the malleus, and the various soft parts which pass through the aforesaid fissure.

Development of the Annulus Tympanicus.—The spina tympanica antica unites with the tegmen tympani and thus completes the petrotympanic fissure posteriorly, but the spina tympanica postica projects beyond or behind the tympanic margin of the squamous portion of the temporal bone, and also behind and above the drum-head, and inserts itself at last into the depression between the head and the handle of the mallet, called the neck, as shown by Henle. Considered as anatomical points these are quite insignificant, but when taken in their physiological relations with the support they give to the malleus they are of great importance. As the bone develops the *spina tympanica antica* grows away, as it were, from the *spina tympanica postica*, and is finally seen at a point far down on the superior wall of the bony portion of the canal, and in the fully developed broad tympanic bone. As, however, the spina tympanica postica of Henle, in the fœtal bone, becomes of so much importance as the anterior point of insertion for the ligaments supporting the malleus in the developed organ, Helmholtz has given to it, in its physiological relations, the name *spina tympanica major;* and to a less prominent point on the postero-superior portion of the ring in which the drum-head is inserted, he gives the name of *spina tympanica minor.* The latter forms the posterior point of insertion for the suspensory ligaments of the malleus. The neck of the malleus fits in between these two points in such a manner that the anterior almost touches it. In the perfect bone this relation is not visible from without.

The line of attachment of the membrana tympani also shows a slight and ill-defined depression where it passes near and beneath these points, *i. e.*, at its upper periphery above the short process of the hammer. Here the line of insertion of the drum-head is less sharply defined than it is lower down the periphery. At this ill-defined point in the upper part of the periphery of the membrana tympani, "slight pressure with a blunt instrument will loosen the membrane from its attachments. In fact it is more truly attached to the cutis than to the bone."[1]

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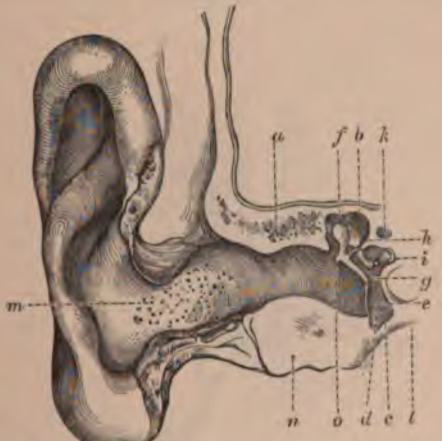
[1] Mechanism of the Ossicles of the Ear and the Membrana Tympani. H. Helmholtz, Bonn, 1869. English translation by A. H. Buck and Normand Smith, New York, 1873.

Segment of Rivinus.—This segment in the upper border of the drum-head is called the segment of Rivinus, since it includes the foramen described by Rivinus, an opening which in some instances represents the last trace of the first visceral cleft, but which really has no existence in the majority of normally developed adults.

The Auditory Canal.—The external auditory canal extends from the bottom of the concha to the drum-head, and consists of a cartilaginous and a bony portion, the former being about one-third, and the latter about two-thirds of the passage.

The length of the auditory canal is about one inch and a quarter, and its average width is about a quarter of an inch.[1] The canal gradually narrows to the middle of the bony portion, where it widens again gradually to the drum-head. A horizontal section, therefore, of this canal will be proximately represented by that of two detruncated cones placed together at their points of detruncation. The auditory canal is lined with skin, a continuation of that of the auricle, and *not* with mucous

Fig. 10.



Vertical Section of the External Auditory Canal, Membrana Tympani, and Tympanic Cavity, Viewed from in Front. (Politzer.)—*a.* Upper osseous wall of the canal. *n.* Lower osseous wall of the same. *b.* Tegmen tympani. *c.* Osseous floor of the tympanic cavity. *d.* Tympanic cavity. *e.* Membrana tympani. *f.* Head of the malleus. *g.* Lower end of the handle of the malleus. *o.* Short process of the malleus. *h.* Body of the incus. *i.* Stapes in the oval window. *k.* Fallopian canal. *l.* Jugular fossa. *m.* Glandular orifices in the skin of the cartilaginous canal.

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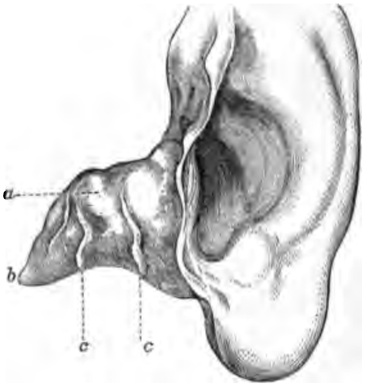
[1] Richet, eight to nine mm. at the opening, and from six to seven mm. at the fundus of the canal. (Hyrtl.)

membrane. The skin of the canal is extended over the drum-head, forming its dermoid or outer layer, so that a glove-finger will represent very well the shape of the cutaneous lining of the canal, the finger-tip being the position of the drum-head. In the bony portion of the canal, the skin is thin and closely adherent, its silvery lustre having probably led earlier observers to call it a mucous membrane; but there is no such membrane in the external ear. In the inferior wall of the meatus there are transverse deficiencies in the cartilage called the *incisuræ Santorini*, and there is a cleft in the upper wall of the cartilaginous part of the canal. The general course of the external auditory canal may be described as sigmoid, or as a spiral turning anteriorly inward and downward, though there are many individuals in whom the auditory canal is so straight that their drum-heads may be seen very easily by direct inspection and without dilatation of the cartilaginous part of the passage. I have frequently inspected the drum-head in such cases without the knowledge of the person examined, sometimes while seated in a public conveyance. Such straight canals are invariably wide ones, and much more common in the black than in the white race.

Fig. 11.



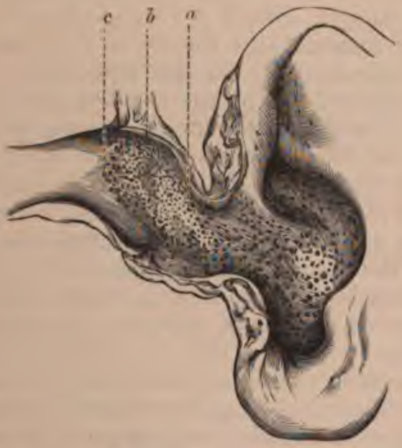
THE AURICLE AND THE CARTILAGINOUS PART OF THE EXTERNAL AUDITORY CANAL (Left Side). (Politzer.)—*a*. Cartilaginous meatus. *b*. Inner pointed end which unites with osseous part of the auditory canal. *c*. Fissures of Santorini.

Although the external auditory canal is usually spoken of as tortuous, I have observed that in the negro it is usually wide and straight, so much so, in fact, that in most cases, in this race, I have been able to see the membrana tympani without the aid of speculum and reflected light, being able to look directly down upon the drum-head. I have sometimes, though very rarely, seen the same kind of a wide and straight auditory canal in the white man.

Could the large auricle and auditory canal have any connection with the musical talent universally found in the negro race in this country? In the white race, the wide and straight meatus, according to my observation, is found in individuals more than ordinarily endowed with the so-called musical ear.

Upon the entire free surface of the cutis of this canal are found epidermis and soft, short hairs, together with the sebaceous glands usually found in connection with them. Throughout the canal, especially in the bony portion, are found vascular papillæ arranged in parallel rows, and glandular structures closely resembling sudoriferous glands, but which in their modified form are called ceruminous glands.

Fig. 12.



Posterior Wall of the Left External Osseous and Cartilaginous Auditory Canal. (Politzer.)—*a*. Openings of the glands in the cartilaginous portion of the external auditory canal and concha. *b*. Triangular space occupied by glands, inserted into the osseous part of the canal. *c*. Boundary between the osseous and cartilaginous parts of the canal.

Ceruminous Glands.—These glands begin about two mm. from the opening of the auditory canal, and extend to within two or three mm. of the drum-head. They are most numerous at the junction of the cartilaginous with the bony canal, where they average as many as ten to the square millimetre. According to Buchanan, there are from one thousand to two thousand in an auditory canal. The thickness of the skin in the cartilaginous part of the auditory canal is one and a half mm. thick.

Vessels and Nerves.—The arteries supplying the auditory canal are branches from the posterior auricular, internal maxillary, and temporal branches of the external carotid artery. The nerves are chiefly derived from the temporo-auricular branch of the inferior maxillary nerve. There is also an *auricular branch* of the pneumogastric nerve. The plexus of the sympathetic nerve, distributed to the external carotid artery, communicates with the otic and submaxillary ganglia, by means of the plexus distributed to the facial and internal maxillary arteries.

PHYSIOLOGY.

The acoustic physiology of the external auditory canal has been alluded to in speaking of the functions of the external ear as a resonator. There is one function it possesses, that of causing the ear-wax and some small foreign bodies to be extruded from it, which has not been fully explained heretofore.

Voltolini[1] has shown that if a foreign body is wedged in a swollen auditory meatus, and the former be made smaller by any means, but especially by the galvano-cautery, the body thus reduced will be pressed out by the swollen walls of the auditory canal. This he claims to be an invariable physical process. Perhaps we may explain the natural escape of cerumen from the ear in some such way as the following: The ear-wax is mostly formed in the wide end of a detruncated cone, *i. e.*, near the outer end of the auditory canal. Therefore, as the wax forms, it presses upon the walls of the auditory canal, and the latter being widest towards the mouth, *i. e.*, freest on the outer side of the gradually growing mass of cerumen, the latter meets with the least obstruction just in the direction of its only escape; hence it will be acted upon very much as if it remained a constant quantity, which is being continually pressed upon from behind, and pushed outward by a gradually narrowing auditory canal; for, as the mass grows larger, it must necessarily, with its naturally lubricated surface, slip into a broader, which is an outer, plane in the external auditory meatus, and thus at last it may be found at the mouth of the auditory canal. Unfortunately, this delicate function is constantly interfered with by those who, in endeavoring to clean out wax, push in more than they bring out, and thus, in a short time, form obstructive plugs of cerumen.

Another mode by which cerumen is aided to fall out of the auditory canal, if let alone, has been suggested to me by watching the gradual outward movement of a scab on the membrana tympani, and of a similar object on the wall of the auditory canal. If a little fleck of blood forming on the membrana tympani, or on the wall of the external auditory canal, be watched for some days, it will be observed to change its position by moving outward, strongly suggestive of the manner in which a spot over the matrix of the finger-nail will gradually grow to the edge of the nail and disappear. I have watched little scabs of blood thus move from the drum membrane to the wall of the canal, and from the inner part of the latter similar substances may be seen to move outward to the meatus. The normal progressive growth of the dermoid coat of the membrana tympani takes place most rapidly, and chiefly in the direction of the superior and posterior quadrant of the membrane.[1] In some such way, I believe the outward growth of the skin of the auditory canal helps to force out the superabundant ear-wax.

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[1] Monatsschr. f. Ohrenh , No. 9, 1872, and elsewhere.

CHAPTER III.

MEMBRANA TYMPANI.

ANATOMY.

THE membrana tympani, or drum-head, is composed of three layers, viz.: the external or dermoid layer; the middle or fibrous layer, also called the membrana propria; and the internal or mucous layer.

The Dermoid Layer.—The dermoid layer of the membrana tympani is a continuation of the cutis of the external auditory canal. This may be seen if the skin of the canal be macerated properly, when the entire cutaneous lining may be removed in the shape of a glove-finger, the tip of which will represent the dermoid layer of the drum-head. In this layer there are, however, no hairs nor follicles such as are found elsewhere in the cutis of the auditory canal. In other respects, it is true skin, but extremely thin and transparent.

The Outer Surface of the Membrana Tympani.—The dermoid layer is the only one of the three layers composing the membrana tympani which can be inspected directly from without. When the ear is illuminated and a normal membrana tympani examined from without, there are several prominent features in it which at once attract attention, viz.: its almost circular shape and peculiar polish and color; its vertical and horizontal inclination; the manubrium of the malleus; the short process of the latter; the folds of the membrana tympani; the flaccid portion of the drum-head above these folds, called the membrana flaccida or Shrapnell's membrane; and the bright triangular reflection of light in its antero-inferior quadrant, called the "pyramid of light."

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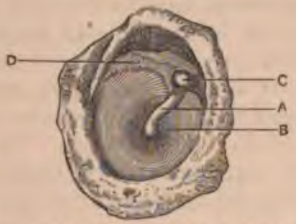
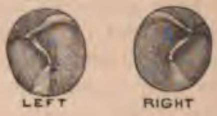
[1] Dr. C. J. Blake, American Journal of Otology, vol. iv., 1882.

Fig. 13.



VIEW OF OUTER SURFACE OF MEMBRANA TYMPANI. (Gruber.)—A. Malleus; manubrium. C. Short process. B. The tip of the manubrium. D. Posterior fold.

Fig. 14.



THE NORMAL MEMBRANA TYMPANI.

Shape of the Membrana Tympani.—For purposes of convenience in description, the outline represented by the periphery of the membrana tympani is called circular. This form, however, varies between that of an ellipse and an irregular oval, while in some cases where the lateral portions of the annulus tympanicus are especially curved outward, it assumes a heart shape.

It may be strictly considered an ellipse, the long diameter of which, amounting to 9–10 mm., runs from above and in front, downward and backward, and the diameter of greatest width of which runs from below and in front, upward and backward. These measurements are those given by von Troeltsch, and are nearly in accordance with those of Hyrtl, according to whom the proportion between the diameters is as 4.3‴–4.0‴.

Since the difference between them is so slight, and their inclinations are so nearly vertical and horizontal, the outline of the membrana tympani may be considered circular, and the long diameter is spoken of as the vertical diameter, while the diameter of greatest width is considered the horizontal diameter.

The membrana tympani is, therefore, divided into quadrants, which greatly aid in locating any point to be described.

Color of the Membrana Tympani.—The normal color of the membrana tympani is never fixed. Just as some normal teeth are bluish or yellowish-white, so it is with the drum-head, which though perfectly normal may be bluish or yellowish-gray, though more frequently it is found to be the former. The normal color of the drum-head is usually spoken and written of, as "pearl-gray," but whatever color the membrana tympani may be said to have, that color *must always be modified* by the physical conditions brought about by stretching a nearly transparent membrane over a darkened cavity. And this is a modification not sufficiently taken into account by observers. There is, therefore, from the cause just mentioned, an admixture of black with the delicate gray of the membrane, but it is very difficult to *paint a transparent* or translucent object, and therefore very difficult to ascribe even a name to the color of a normal membrana tympani, since its appearance is partly due to the color which its own substance reflects and partly to the color it transmits from the cavity of the drum, the latter feature of course being modified in every imaginable degree by the thickness or thinness of the membrana tympani, as well as by the various conditions and colors of the contents and mucous lining of the tympanic cavity.

Modifications of color similar to those in the membrana tympani can be in a measure produced artificially, if we stretch a piece of gold-beater's skin, delicate tissue paper, or sheet gutta-percha over a rather shallow cavity darkened by covering it in this manner. The color of the membrane thus formed will be composed of the latter's own peculiar tint as an opaque substance and the color of the cavity over which it is stretched and which it transmits.

"That part of the membrana tympani just behind the lower end of the manubrium, and over the promontory of the cochlea, is rendered yellowish-gray by the rays of light reflected from the yellow bone of the inner wall of the tympanic cavity" (Politzer). Of course, all these shades of color vary a little, even in the normal state; but greatly during pathological processes in any part of the structures entering into the formation of the drum-head.

The membrana tympani owes its peculiar lustre to the delicate and shining epithelium of the dermoid layer. If a fresh membrana tympani be placed in a solution of nitrate of silver, the peculiar cement-like substance between the scales of this epithelium will become tinged, while the scales themselves will remain uncolored, and thus a distinctly marked preparation will be made in which the various shapes of the epithelial scales become demonstrable under the microscope.

The slightest maceration or exfoliation of this delicate epithelium deprives the membrana tympani of its beautiful gloss. The dermis of the drum-head is thickest in children.

The Inclinations of the Membrana Tympani.—Another important fact which attracts the attention of one examining the ear is, that the membrana tympani, in its normal condition, is inclined outward at an angle of 45° in its vertical plane, and in its horizontal plane is inclined 10° towards the right on the right side and 10° towards the left on the left side. If the planes of both membranæ be extended downward until they intersect each other, the angle which they will thus form will be equal to about 130°–135°.

Of still greater importance than this, however, is the direction of the walls of the auditory canal from the plane of the membrana tympani. Thus if a perpendicular be drawn from the upper pole of the drum-head to the inferior wall of the auditory canal, it will strike the latter about 6 mm. from the inferior pole of the membrane.

A similar result will be obtained by drawing a perpendicular from the middle of the posterior periphery of the drum-head to the anterior wall of the auditory canal, from which fact it becomes very evident that the antero-inferior part of the membrana tympani is further removed from the external opening of the auditory canal than the postero-superior part.[1]

The membrana tympani is inclined the most in very young children, being in the early years of life almost horizontal in position, and, on account of the shallowness of the auditory canal at that time, the membrane is very superficial, especially at its upper part.

In some instances there is observed a physiological variation in the obliquity of the membrana tympani, and a filling in with osseous tissue, of the segment of Rivinus. Hence, on inspection there is found a large portion of the field at the fundus of the canal taken up by the upper wall of the canal, which seems to dip down to join the membrana tympani on a line with its folds. In these cases there is very little or no membrana flaccida. This condition I have observed in the feeble-minded with some other defective cranial development. Moos and Steinbrügge[2] have observed in the same individual, a cretin, with defective cranial development, a difference of the inferior angle of the membrana tympani, of 40°, on each side. The difference in such cases may be from 10° to 50° greater than normal.

The Manubrium of the Malleus.—Running from above downward and backward to the centre of the membrana tympani is seen the ridge formed by the manubrium of the malleus.

This slightly elevated ridge, entirely opaque and decidedly whiter than the surrounding drum-head, divides the membrana tympani into two unequal parts, the anterior being the smaller and the posterior the larger. At the upper end of this ridge is the *short process* of the malleus, projecting sharply outward, somewhat above the general surface of the handle of the hammer. In general appearance it is not unlike a pimple with yellowish contents.

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[1] Gruber, Studien über das Trommelfell, p. 4.

[2] Archives of Otology, vol. xi., 1882.

The lower end or tip of the ridge, which curves slightly forward, is flatter, broader, and yellower than the rest of the outer covering of the manubrium. This is due to the fact that the bone proper is spade-shaped at this point, and also because the radial fibres of the membrana propria centre at this lower part of the bone. The lower end of the manubrium draws the membrana tympani inward very markedly, and forms that depressed spot in the centre called *the umbo.*

The convex shape of the drum-head from the tip of the manubrium outward towards the periphery is due to the comparatively large number of circular fibres at a point between the umbo and periphery, which constrict, as it were, the radial fibres, so as to form a kind of funnel.

Fig. 15.

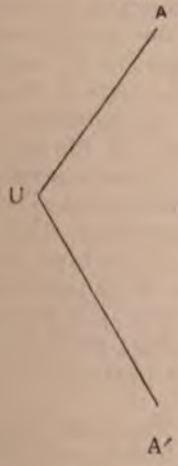
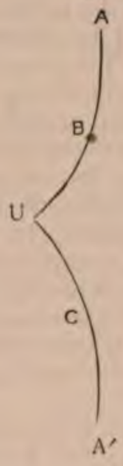


Fig. 16.



Pressure or traction applied to the centre of a membrane stretched over a ring, tends to draw the former into a cone, a vertical section of which is represented by the line A U A′ in Fig 15. But if a smaller concentric ring be placed at B C so as to resist the indrawing force at U, the curve assumed by the membrane is represented by the line A U A′ in Fig. 16, and the whole membrane is drawn into a concavo-convex shape.

The Yellow Spot at the End of the Manubrium of the Malleus.—This spot is not a pathological appearance, but a purely physiological condition. It is part of the cartilaginous structure at the end of the hammer.

Dr. Trautmann,[1] who has made a special study of the spot, concludes that: 1. Its physiological significance is the same as an epiphysis of a long bone. 2. The diagnostic value of the yellow spot is apparent in cases of thickening of the membrana tympani, when the former will disappear much sooner than the sharp edge of the malleus. 3. Opacities of the membrane with thickening change the color of the yellow spot. 4. When the malleus is twisted on its long axis the form of the spot will be altered. 5. If the spot does not move during alterations in the atmospheric pressure in the canal, by means of Siegle's speculum, it is fair to conclude that either ankylosis of the malleus or its adhesion to the inner wall of the tympanic cavity has occurred. In the latter instance the differential diagnosis is aided by the necessary foreshortening of the handle of the hammer.

Folds of the Membrana Tympani.—From the short process of the manubrium of the malleus two delicate ridges may be seen, one passing forward, the other backward to the periphery. These are the so-called folds of the membrana tympani. They are formed by the pressure outward of the short process of the malleus. They are important topographical as well as diagnostic points of the membrana tympani. Above these folds is the so-called membrane of Shrapnell,[2] or membrana flaccida. It owes its flaccidity to the small amount of fibrous tissue entering into its composition, and to the loosely stretched cutaneous and mucous layers of the membrana tympani, which here come together. In this membrane somewhere, there was once *said to be* a normal opening, the foramen of Rivinus, named after the writer, who first called attention to its supposed existence in 1717. Ever since, the dispute has turned upon several points, viz., first, whether there is such an opening; secondly, is it normal or pathological; and, lastly, in what part of the membrane is it found.

Although a number of distinguished observers, among whom may be quoted Patruban, Gruber, Politzer, and Hyrtl, have investigated this point in the anatomy of the membrana tympani, the question was for a long time an open one, until Hyrtl denied the existence of a normal opening in the membrana flaccida, either in the adult or in the infant cadaver. He, how-

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[1] Archiv f. O., Bd. xi. pp. 99–113.

[2] Henry Jones Shrapnell, not Odo Shrapnell, as several German authors have called him. This author's description of the membrana flaccida is found in the London Med. Gazette, vol. x. p. 120.

ever, admits that a *want of development in the membrane* in the neighborhood of the Rivinian segment may, in some cases, lead to the formation of a quasi foramen, but the normal existence of such a foramen is not proven. Such testimony as Hyrtl's is incontrovertible in the author's opinion, and can never be overthrown by the assertion that the opening is so small that the anatomist must look for hours with a magnifying glass in order to find it; nor can I understand how a foramen should be so small as to require such persistent search with a magnifying glass, and yet, when found, be large enough to allow a bristle to pass in and through it.

Pyramid of Light.—The pyramid of light is a name applied to the beautiful triangular reflection of light emanating from the antero-inferior quadrant of the normal membrana tympani. The apex of this triangular reflection touches the tip of the manubrium of the malleus, and its base lies on the periphery of the membrana tympani. It forms, with the handle of the malleus, an obtuse angle anteriorly, which becomes greater as the inclination of the membrana tympani to the auditory canal diminishes. Its average height is from 1½ to 2 mm., and its average width at the base is from 1½ to 2 mm. This reflection, which has been called an isosceles triangle from its general appearance, is, strictly considered, pyramidal in shape, and hence the name applied to it by most writers of the present day.

The causes of the formation of this pyramid of light, or, in other words, the optics of this important spot, have been variously explained by a number of careful observers. Wilde, the first to describe it, believed it to be due to the convexity of the membrane, but other observers since that time, among whom may be named Politzer,[1] Gruber,[2] Voltolini,[3] and Trautmann,[4] have most clearly shown that such a convexity is not the only cause of the formation of the pyramid of light. From the more recent investigations, it is most conclusively proven that there are three elements indispensable to the formation of this peculiar reflection of light, viz., a shining surface, the inclination of the membrane, and its peculiar funnel-like shape. In these three conditions may be found the solution of three very important questions, viz.: 1. Why do we see such or any reflection from the membrana tympani? 2. Why do we see this one in the antero-inferior quadrant? And, 3. Why is its shape pyramidal?

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[1] Die Beleuchtungsbilder des Trommelfells im kranken und gesunden Zustande, Wien, 1865.

[2] Anatomisch. Physiologische Studien, über das Trommelfell und die Gehörknöchelchen, Wien, 1867.

[3] Monatsschr. f. Ohrenh., Jahrg. vi., No. 8.

[4] Archiv f. Ohrenheilkunde, Band ii., N. F., 1873.

The *first* condition, viz., the reflecting surface, is supplied by the lustrous epithelium of the dermoid layer of the membrana tympani, and thus an answer is given to the first question.

The *second* condition, viz., the peculiar inclination of the membrana tympani, so places the membrane that, by the modifications of its surface brought about by the traction inward at the umbo, the only possible spot from which light can be reflected is just where the pyramid of light is seen. This point will be more fully explained further on.

The *third* condition, viz., the funnel shape of the membrana tympani, will explain the pyramidal shape of this reflection, upon the physical law pertaining to concavo-convex mirrors.

Not one of these conditions is sufficient of itself to produce a normal pyramid of light on the drum-head. That the lustre of the dermoid layer is an important factor in producing this peculiar reflection, may be easily proven by syringing an ear in which the pyramid of light is seen in its normal condition. After a slight maceration of the dermoid layer has been thus produced, and its shining surface destroyed, the pyramid of light will be found to have disappeared or to have become dulled or distorted.

In order to prove that the peculiar inclinations of the membrana tympani, respecting the walls of the auditory canal, have also their part in the formation of the pyramid of light at that point where it is normally found, viz., in the antero-inferior quadrant, it is only necessary to inspect a normal drum-head in which the reflection of light, in question, is found, during the inflation of the tympanic cavity by the Valsalvan or any other method. It will then be seen that the pyramid of light becomes altered in its *position in respect to the malleus.* That this reflection can come only from the antero-inferior quadrant is further shown by an experiment of Politzer's, as follows:

If the auditory canal be removed from the membrana tympani, so that the latter is attached only to the annulus tympanicus, and the membrane then be revolved, so that other parts of its surface successively assume the position of that from which the pyramidal reflection formerly came, we shall perceive on each of these parts a reflection almost exactly like the original pyramid of light, excepting behind the manubrium, where, owing to the different curve of the membrane, the reflection in question will be somewhat different, both in shape and brilliancy.

The third important condition in the formation of the pyramid of light, is the funnel shape of the membrana tympani, to which is due, according to Trautmann, the pyramidal shape of the reflection under consideration.

The Cause of the Pyramidal Shape.—It is already known that the membrana tympani is drawn inward in such a way by the manubrium of the malleus and the peculiar distribution of fibres in the membrana propria, that its general shape may be likened to that of a shallow concavo-convex funnel or the flower known as the "morning-glory" or convolvulus.[1]

As its surface is very polished it may be considered a convex mirror, which, for the sake of better explaining the pyramidal shape of the light spot of the membrana tympani, we may consider a convex mirror composed of an indefinite number of sections of convex mirrors with radii varying from that of a mere point to that of the circle which the periphery forms. Now, since it is a law of physics that the image reflected from convex mirrors varies in size directly as the radius of the mirror, we shall have in the composite convex mirror represented by the drum-head, an image, which at the centre, *i. e.*, at the point of the manubrium, is a mere point of light, but which gradually enlarges towards the periphery, until we perceive a triangular spot with its base on the periphery, the height of which depends on the distance of the centre of the mirror from the periphery, and the breadth of the base of which depends on the dimensions of the periphery; the greater the latter the wider the base of the triangle of light.

Dr. Trautmann thus sums up the causes of the pyramid of light: "The normal membrana tympani has quite a high degree of superficial lustre, is inclined at an angle of 45° in its vertical plane, and in its horizontal plane it is inclined 10° towards the right on the right side, and 10° towards the left on the left side. Furthermore, it is drawn inward so as to form a concavo-convex funnel, the point or apex of which lies in the centre of the anterior periphery of the yellow, sickle-shaped expansion at the end of the anterior edge of the manubrium of the malleus, the angle at which the walls of the funnel meet is greater than a right angle, the depth of the funnel is equal to about 2 mm., and the distance from the apex to the periphery is 2½–3 mm. anteriorly, and 3 mm. posteriorly.

"But a reflection of light from the surface of the membrana tympani, were it flat, could not reach the eye of an observer, because the rays of light from without, on account of the inclination of the membrana tympani, would fall upon the plane surfaces of the same, at a very acute angle, and since the angle of reflection is equal to the angle of incidence, the rays of light reflected from the planes of the membrane, the latter having an inclination of 45°, would strike the inferior wall of the external auditory meatus, and in consequence would be unable to reach the eye of the observer.

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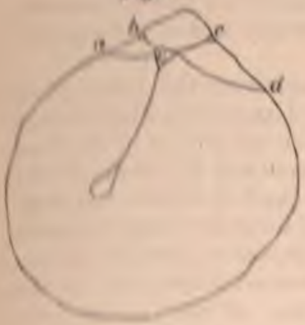
[1] Voltolini, loc. cit.

"The relations are, however, different, when we consider the 'reflection of light' which is found in the concavo-convex, funnel-shaped tract. On account of the vertical inclination of 45° of the membrana tympani and of its horizontal inclination of 10°, and also because of its concavo-convex shape, the antero-inferior quadrant of the membrana tympani is drawn at right angles to the illuminating object. Since, now, the illuminating body and the eye are in the same line, or should be, in order to obtain the best possible illumination of the membrana tympani, only the rays of light which fall perpendicularly upon the antero-inferior quadrant can reach the eye, since all other rays are reflected at such an angle that they strike the walls of the auditory canal; therefore, the only reflection of light seen by the observer comes from the antero-inferior quadrant of the membrana tympani."[1]

Geometric Divisions of the Membrana Tympani.—Kessel[2] has suggested a division of the membrana tympani into two grand tracts, one above, the other below the folds of the drum-head, *a e*, *e d*. The upper tract is subdivided into three sectors, viz., *a e b*, *b e c*, and *c e d*, Fig. 17. The *sectors* are bounded below by the folds of the membrana tympani, and above by the annulus tympanicus and the segment of Rivinus, *b c*. The middle sector, *b e c*, is separated from the other two on each side by the two suspensory ligaments, *b e*, *e c*, of the handle of the hammer. Between the anterior suspensory ligament, *b e*, and the anterior fold of the membrana tympani lies the anterior sector, and between the posterior suspensory ligament and the posterior fold of the membrana tympani lies the posterior segment. The inferior division of the membrana tympani, viz., that portion below the *folds*, is divided into an anterior segment beginning at the anterior fold of the membrana tympani and extending to the pyramid of light, and the posterior segment extends from the pyramid of light to the posterior fold of the membrane.

Fig. 17.



According to Kessel, making the pyramid of light the inferior boundary between these segments is not arbitrary, but has a good reason in the fact that the radial fibres, running downward and forward, *i. e.*, in the tract of the triangle of light, from the point of the manubrium of the malleus, in a drum-head of normal position, are shorter, and, therefore, tenser and more retracted than those fibres which run directly backward and forward from the manubrium.

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[1] Loc. cit., p. 98.

[2] Ueber den Einfluss der Binnenmuskeln der Paukenhöhle auf die Bewegungen und Schwingungen des Trommelfells am todten Ohre. Archiv f. Ohrenheilkunde, N. F., Band 2, 1874.

Annulus Tendinosus.—Before considering the membrana propria, the structure from which the fibres of this middle layer of the membrana tympani originate demands a short description. This is the so-called annulus tendinosus,[1] or tendinous ring of Arnold. It is a mass of fibrous tissue arranged around the periphery of the membrana tympani, effecting the union between the latter and the inner edge of the éxternal auditory canal.

The *annulus tendinosus* is not found, however, at that part of the periphery of the membrana tympani corresponding to the Rivinian segment, nor is it always visible from without, even when present in its normal position, around the periphery close to the annulus tympanicus.

The fibres of the membrana propria, the origin of which has just been explained, are not inserted directly into the bone of the manubrium, but into a cartilaginous groove which receives the manubrium and short process. This peculiar structure was discovered and has been fully described by Gruber.[2]

It presents in general the appearance of a deep groove, when seen from behind after the removal of the malleus. As shown by Gruber, this groove is closed at its upper end so that it forms a cartilaginous cap, which covers in the short process on all sides; its lower end, on the contrary, is open behind, and it gradually becomes shallower, *i. e.*, flatter, until it is at last lost in the substance of the membrana tympani. It extends from a little above the short process to a point ½ mm. below the spade-like end of the manubrium.

Inner Surface of the Cartilaginous Groove.—The inner surface of this cartilaginous groove, which is in contact with the malleus, is lined by a very delicate layer of connective tissue, between which and the malleus there is found a small amount of fluid resembling synovia. As this condition of discontinuity between the malleus and the inner surface of the cartilaginous groove is considered normal by Gruber, it is fair to presume that, such being the case, the malleus can make a certain amount of motion in this groove, and that therefore there is here a kind of joint.

I have seen in Gruber's clinic, and often in my own practice, cases which appeared to have *two* short processes projecting from the upper end of the manubrium. Such an appearance is explained by Prof. Gruber as the result of a dislocation or slipping upward of the entire malleus out of this cartilaginous groove; the upper of the "two short processes" in such a case is the true bony short process, whereas the lower one is the aforesaid cartilaginous cap, moulded over the short process, and held in the original position of the true short process by the membrana tympani. This condition, Gruber calls subluxation of the cartilage from the short process. Köllicker[1] regards this *hyaline* cartilage as a remnant of the cartilaginous malleus of fœtal life, and he thinks it is very possible that the osseous malleus is formed about the cartilage, as is the case in the *processus spinosus*, in which instance the layer of connective tissue found by Gruber between the cartilaginous groove and the malleus, and the comparatively easy separation of the two from each other become perfectly explicable, but Köllicker does not admit that there is a normally developed and constant space between these two structures.

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[1] The annulus cartilagineus of the older writers.

[2] Studien über das Trommelfell, Vienna, 1867, u. s. w., pp. 20–27.

The Membrana Propria: the fibrous or middle layer of the Membrana Tympani.—Having considered the anatomy and the inspections of the outer or dermoid layer, the anatomy of the middle or fibrous layer of the membrana tympani demands attention. The *membrana propria* can be subdivided into two distinct and delicate layers, viz., an *outer*, composed entirely of radiate fibres intimately connected with the dermoid layer of the drumhead; and an *inner* layer, composed entirely of circular fibres, in close relation with the mucous membrane composing the internal layer of the membrana tympani. These component layers of the membrana propria are named, briefly, the radial and the circular layer. The fibres composing the former arise from the annulus tendinosus and the upper wall of the auditory canal, and are inserted into the manubrium of the malleus, centring for the most part at its spade-like tip. The fibres composing the circular layer arise partly from the annulus tendinosus, but the majority of them arise from the substance of the membrana tympani itself (von Troeltsch). Some of them are inserted into the malleus.

Of the former kind, viz., those arising from the annulus tendinosus, Gruber says: "They form a very acute angle with the annulus tendinosus, assuming in their progress downward the course of the fibres of the circular layer." These fibres, Gruber thinks, have either been overlooked heretofore, or considered radial fibres. The circular fibres are most numerous a short distance from the periphery of the membrana tympani. The region of their greatest thickness is in the outer third of the membrane, where they are twice as numerous as the radial fibres; the thickness of the circular layer at this point being 0.026‴, while that of the radial layer is equal to 0.018‴ (Gerlach). They are much less numerous at the middle third of the membrane, and almost wanting at the central part of the drum-head. A knowledge of the arrangement of these fibres is important when considering pathological changes which may have taken place in the membrana tympani, and also in explaining the peculiar concavo-convex shape of the drum-head. "If the radial fibres of the membrana tympani were not united by transverse ones, they would be stretched in a straight line. In point of fact, however, they maintain a curved shape, with the convexity looking toward the meatus; hence we conclude that the radial fibres are drawn toward one another by circular fibres, and that the latter are also made tense at the same time. There is, in fact, in the membrana tympani at rest, no other force capable of holding the radial fibres in a curved position, except the tension of the circular fibres."[1]

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[1] Gewebelehre, p. 707.

The Descending Fibres of the Membrana Tympani.—In addition to the two layers already described as forming the membrana propria, there is still another layer composed of descending fibres, first described by Gruber.

These fibres are external to the radial fibres, and arise from the upper segment of the annulus tendinosus, and, lying very close to each other, are inserted into the sides and median line of the cartilaginous groove already described.

The various layers of the membrana propria, *i. e.*, the three just described as the radial, circular, and descending fibres, are lightly bound together by a very delicate kind of connective tissue. On the other hand, they cling very firmly to the annulus tendinosus, cartilaginous groove, dermoid and mucous layers, as shown by Gruber.

Arborescent Fibrous Structure of the Membrana Tympani.—There is in the membrana tympani a set of fibres arranged in a peculiar way and first described and named by Gruber the dendritic fibrous structure[2] of the drum-head.

"They arise near the periphery, about in the middle of the posterior segment, pretty far apart, but as they proceed on their upward course in the posterior segment they approach each other, in order to divide again, at some distance from the manubrium of the malleus, into several branches, usually about three, which run in different directions, and are finally lost by inter-

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[1] Helmholtz: Mechanism of the Ossicles of the Ear and the Membrana Tympani, English translation by Buck and Smith, New York, 1873.

[2] Dentritisches Fasergebilde.

twining with the fibres of the membrana propria."[1] These fibres are not confined to the posterior segment, but traces of them are found throughout the membrana tympani.

At their peripheral portion they are between the two layers of fibres composing the membrana propria, but as they approach the centre they are in intimate connection with the mucous layer of the membrana tympani. These fibres are of dense connective tissue, closely resembling tendon. When treated with acetic acid, they exhibit the peculiar connective-tissue corpuscles already alluded to as being found in the membrana propria.

Prof. Gruber further shows that the fibres entering into the composition of this structure, become most beautifully manifest when viewed by polarized light, when they appear much more brilliantly illuminated than the other tissues of the membrana tympani. Respecting the function of this structure we are told that in all probability it is an apparatus for relaxing the membrane, although it cannot be shown as yet that it is a muscular structure.

Constituent Elements of the Membrana Propria.—The labors of Toynbee, v. Troeltsch, Gerlach, and Gruber have added to the knowledge of the nature and dimensions of the constituent elements of the *membrana propria*. It consists chiefly of connective tissue of that variety halfway between the ordinary fibrillated and the homogeneous connective tissue of Reichert, as shown by Gerlach.

The fibres are 0.004‴ broad and 0.002‴ thick, and on account of their ribbon-like shape they were once supposed to be unstriated muscle fibres, which they are not. On these fibres, certain peculiar spindle-shaped corpuscles are found. The latter were supposed to be peculiar to the membrana tympani, and have been called "corpuscles of the membrana tympani," or the "corpuscles of v. Troeltsch," after the observer who first drew attention to their existence. They are, however, connective-tissue corpuscles of Virchow. They are about 0.002‴ long and from 0.005‴ to 0.010‴ wide at their broadest part, with from two to three processes.

According to Gruber, these bodies are found in two varieties in the membrana tympani, viz., the spindle-shaped and the stellate variety.

The Internal or Mucous Layer of the Membrana Tympani.—The internal layer of the membrana tympani is composed of mucous membrane, a reflection of that lining the tympanic cavity. It is thickest at that point where it leaves the cavity of the middle ear and passes over the periphery of the drum-head. It grows gradually thinner as it approaches the centre of the membrana tympani, where it is extremely delicate.

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[1] Gruber, Studien über das Trommelfell, p. 35.

On the inner surface of this layer various observers, among whom may be named Politzer, Gerlach, and Kessel, have found villi or papillæ. They are said by Gruber to resemble intestinal villi in their appearance. They are usually found in delicate children. These villi may be globular or finger-shaped, the diameter of the former being from 0.10‴ to 0.12‴, and the length 0.12‴ to 0.14‴; the finger-shaped ones vary in length from 0.10‴ to 0.12‴, and in width 0.06‴ to 0.08‴. (Gerlach and Gruber.)

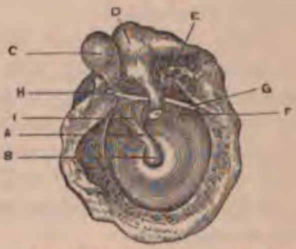
Since Gerlach could not discover any nerves in these bodies, and as some of them are connected with the mucous membrane only by means of pedicles, he is disposed to regard them as villi rather than as papillæ.

Fold of Mucous Membrane for the Chorda Tympani.—The mucous membrane of the tympanic cavity covers the entire inner surface of the membrana tympani; near the upper boundary of the latter it is reflected over the chorda tympani and back again to the drum-head.

By this means a duplicature or fold of mucous membrane is formed, the opening of which is turned towards the surface of the membrana tympani, and in the cul-de-sac or inner edge of which the chorda tympani is found.

Pouches of the Membrana Tympani.—The fold is adherent to the inner surface of the neck of the hammer, and being thus divided into an anterior and posterior portion, contributes to make the inner boundaries or sides of the two pouches of the membrana tympani described by von Troeltsch. Further explanation of the pouches will be given under the consideration of the contents of the tympanic cavity.

Fig. 18.



View of Inner Surface of Membrana Tympani. (Gruber.) — A. Manubrium of malleus. B. The tip or lower end of manubrium. C. Head of malleus. D. Body of incus. E. Short process of incus. F. Processus lenticularis of incus. G. H. Chorda tympani. I. Insertion of tensor tympani.

Vascular Supply of the Membrana Tympani.—The membrana tympani obtains its blood-supply from the tympanic branch of the inferior maxillary artery, and also by means of a short, direct branch from the *internal carotid* in the carotid canal. By the latter channel, the membrana may become quickly engorged.

Comparative Distribution of Bloodvessels in the Membrana Tympani.—In a series of investigations upon the membrana tympani of the mammalia, I have found in the dog, the cat, the goat, and the rabbit, an arrangement of the bloodvessels not heretofore described, and totally different from that in man.[1]

Prussak,[2] in his brochure upon the circulation of the blood in the tympanum of the dog, has represented the general topography of the vascular system in the membrana tympani of that animal, but he does not point out the ultimate *loop-like* arrangement of the vessels distributed over the surface of the membrane. The plate which accompanies his article seems to indicate that the delicate vascular loops have been broken by the force of injection, and thus have escaped the eye of the observer.

In my investigations I have found that from the periphery of the membrane a series of vessels run directly towards the manubrium of the malleus; then each vessel, at a point from one-half to one-third of the distance between the periphery of the membrane and the manubrium of the malleus, turns *abruptly* upon itself and returns to the periphery, and thus there is formed a series of *vascular loops* at nearly equal distances from one another around the edge of the membrane.

A similar series of loops run both anteriorly and posteriorly from the manubrium of the malleus towards the periphery of the membrana tympani, a diagram of which may be seen in Fig. 19, representing the membrana tympani of a dog magnified eight diameters.

This arrangement of vessels in the membrana tympani is constant in the dog, the cat, the goat, and the rabbit, in consequence of which a portion of the membrane between the annulus tympanicus and the manubrium of the malleus remains free from capillaries in its normal condition, and it is probable, though not yet proven, that ordinary disturbances in the circulation are not likely to interfere with the vibrations of the membrane in these animals.

These vascular loops do not exist in the guinea-pig, an animal which has in its membrana tympani an arrangement of vessels peculiar to itself. The general appearance of the membrana tympani of the guinea-pig, under the microscope, is much more transparent and delicate than that of any of the previously mentioned animals.

The vessels in the membrane of the guinea-pig are arranged in the form of a net, with coarse mesh of quadrangular or pentagonal shape. The radiate fibres are strongly developed in comparison with the circular fibres, which are sparsely distributed throughout the texture of the membrane. They are, however, readily seen, and present an appearance as peculiar to the membrana tympani of the guinea-pig, as the shape of the mesh of the network of bloodvessels in the membrane of this animal. In no other membrane have I seen as distinctly the blood-corpuscles lying within the capillaries as in that of the guinea-pig.

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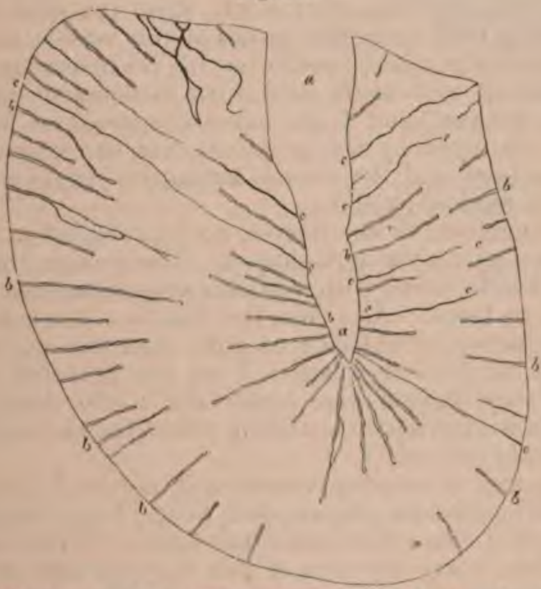
[1] American Journal of the Medical Sciences, January, 1873.

[2] Verhandlungen der Königlich. Sächsischen Gesellschaft der Wissenschaften zu Leipzig, 1868.

Fig. 19.



MEMBRANA TYMPANI OF A DOG.—The wood-cut is from a drawing of a chloride of gold preparation made by and in the possession of the author. *a*, *a*. Vacancy left by manubrium of malleus. *b*, *b*, *b*, *b*. Vascular loops. *c*, *c*. Ordinary capillaries.

The membranes which show these loops and other vascular arrrangements most distinctly are such as have been colored with a solution of the chloride of gold (one-half per cent.). The vascular arrangement can be seen, but not very satisfactorily, in membranes which have been treated with osmic acid or a solution of carmine. The best specimens, showing not only bloodvessels, but in many cases the delicate nerves of the membrane, I have obtained by preparing the membrana tympani of the dog in the following manner: Remove the membrane from the animal as soon as possible after death. In the majority of my experiments, the animal had been dead but a few minutes. Steep the membrane a few seconds in concentrated acetic acid; then lay it in a solution of chloride of gold, which should be kept at a temperature somewhat above that of the blood, for one-half hour. After this treatment, the membrane should remain twenty-four hours in glycerine, or water slightly acidulated with acetic acid, and exposed to the light till it assumes a delicate purple hue. The older the preparation becomes, the more distinctly are the vessels colored. I have some preparations, mounted in glycerine, now almost a year old, which are better than the day they were made, since the gold has taken an increasing hold upon the tissues of the vessels and nerves. After a number of trials, I prefer leaving the membrane in glycerine acidulated with acetic acid, since it demands less care in respect to renewal, and I am never chagrined at finding the specimen destroyed by the evaporation of the water. By this process the *loops*, and the nerves accompanying them, are most likely to be rendered visible.

The arrangement of the nerves, not represented in the woodcut, is best described as fork-shaped. The prongs embrace the loop; the handle unites with a similar projection from the opposite series of loops. As a rule, the vessels color more readily under the action of chloride of gold than the nerves. How this might be in clear weather, I am not prepared to say, as all of my experiments were performed in the cloudy weather of a Vienna winter, notwithstanding which, the nerves frequently became richly colored.

This method of coloring vessels and nerves I have applied only to the membrana tympani, and, hence, I can claim no superiority for it in connection with other tissues. When it succeeds, it is superior to any injection of this very delicate membrane, since the vessels and nerves are rendered visible with a distinctness characteristic of the action of chloride of gold, a reaction to which attention was first called by Cohnheim.

The bloodvessels are rendered distinct, without becoming opaque, so perfectly in most cases that we can detect the blood-corpuscles lying within the capillary. The vessel, furthermore, retains its normal calibre and position, whereas, when we resort to injections, the vessels are apt to be unduly distended, are necessarily opaque, extravasation of coloring matter may take place, or the vessel may be ruptured.

The method is more convenient than injection, and as no mechanical force is used, the field of the microscope must of necessity present a very true picture of the tissues as they are in their normal state. The application of this method of coloring to the membrana tympani of man shows the *absence* of the vascular loops already described, and reveals an arrangement of the vessels similar to that obtained by other observers with injections.

The arrangement of the vessels is not unlike the vascular network in the membrana tympani of the guinea-pig. In man, however, the mesh is much finer, the vessels coarser. The fibrous layer is, on the other hand, very thick, and is more equally composed of radiate and circular fibres than the membrane in the guinea-pig.

Since the membrana tympani of man is supplied by a dense network of vessels, the gold method of coloring it is superior to the usual method by injection, as the entire preparation is less opaque than when the vessels are filled with Prussian blue, carmine, etc.

It may, therefore, be concluded that:

1. There is a distribution of vessels in the membrana tympani of man peculiar to him.
2. There is a distribution of vessels in the membrana tympani of the dog, the cat, the goat, and the rabbit, constant in, as well as peculiar to them.
3. A distribution of bloodvessels exists in the membrana tympani of the guinea-pig peculiar to it.

SECTION II.

MIDDLE EAR.

CHAPTER I.

TYMPANIC CAVITY.

ANATOMY.

UNDER the term Middle Ear are included the tympanic cavity and its two very important adjuncts—the Eustachian tube in front, and the mastoid portion of the temporal bone, and its cells, behind.

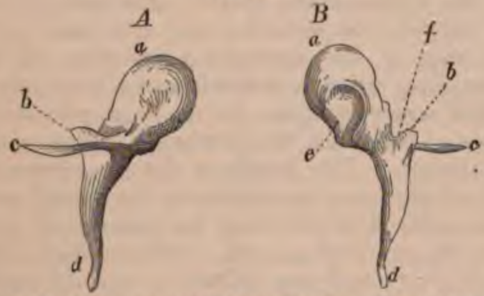
Ossicles of Hearing.—In the tympanic cavity of all mammals, are three small bones: the *malleus* or hammer; the *incus* or anvil; and the *stapes* or stirrup.

Anatomists of a later day have shown that the once so-called *os orbiculare*, or *os Sylvii*, does not exist as a separate ossicle. That which once received this name is the *processus lenticularis* of the long process of the incus, which fits into a corresponding depression in the head of the stapes.

The Malleus.—The malleus, or mallet, received its name from Vesalius, and although some anatomists have failed to see the resemblance to this implement, the ossicle still retains its name, and is divided into head, neck, and handle. At the junction of the handle with the neck, are two important processes, viz.: the *short process* on the outer surface, which, when in its normal situation, pushes the membrana tympani ahead of it, and points towards the auditory canal, and the *process of Rau* or *Folius*, which passes anteriorly into the Glaserian fissure. In the fœtus and new-born child, this process is about 3½ lines long, and can then be removed whole. After birth it unites with the under wall of the Glaserian fissure, and when the malleus is removed, only a short piece of the former long process is found attached to it. This remnant was all that was known of the long bony process, to the older anatomists, and it has been called the processus Folianus,[1] after Folius, who, in describing this process, alluded only to the remnant.

This process, in its most perfect osseous state, was fully described by Jacob Rau[2] in his lectures, and his pupils, Valentin[3] and Boerhaave,[4] call him the discoverer of it. Hence in its perfect state it is called the processus Ravii, after Rau or Ravius. This process has also been called the *processus longus seu spinosus*.

Fig. 20.



RIGHT MALLEUS: A, FROM IN FRONT; B, FROM BEHIND. (Magnified 4 diam.: Henle.)—*a*. Head. *b*. Short process. *c*. Long process. *d*. Manubrium. *e*. Articular surface. *f*. The neck.

It is united to the Glaserian fissure, in adults only, by a mass of ligamentous tissue, which favors slight motion in any direction.

The *head* and *neck* of the malleus project into the tympanic cavity, and are entirely free from the membrana tympani. The rounded, smooth surface of the head is directed anteriorly, while the surface which articulates with the incus is directed backward. The long diameter of its articular surface runs vertically; the short diameter, horizontally.

In the direction of the former, the articulating surface has been said to resemble a saddle, for the surface is divided a little below the middle by a horizontal ridge, and depressed on each side of it. This articulating surface is also concave in the direction of its short diameter, *i. e.*, from without inward.

If a shallow oval basin, the long diameter of which is considerably greater than its short diameter, be placed across a ridge, and then bent downward, and at the same time slightly twisted on itself, the cavity thus formed will fairly represent the articulating surface of the malleus.

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[1] Caelius Folius, Venice, 1645. Nova auris internæ delineatio.

[2] Jacobus Ravius, Professor of Anatomy and Surgery in the University of Leyden.

[3] 1719.

[4] Prælectiones, p. 358.

The *neck* of the malleus lies between the head and the manubrium. It makes, with the former, an angle of about 135° when viewed from in front. It has three surfaces: a *broad inner* one directed towards the tympanic cavity, bounded in front by the processus Ravii, or long process, and behind by the long, low bony elevation for the insertion of the tendon of the tensor tympani; *an anterior surface*, lying above the ridge joining the processus brevis and the processus longus, and extending to the angle made by the head of the malleus with the neck, and separated from the posterior surface by a sigmoid-shaped ridge for the insertion of the ligamentum mallei externum of Helmholtz. The *posterior surface* lies between the aforesaid sigmoid ridge in front, the edge of the articulating surface of the malleus above, the low, long process behind, and a line drawn from the insertion of the tensor tympani to the short process below. Of all the surfaces of the neck, the posterior glides most gradually into the manubrium. The *handle* or the *manubrium* of the malleus, that part of the bone inserted into the membrana tympani, has also three surfaces, which may be considered prolongations downward of those of the neck. Since they all gradually approach each other and are united in the tip or point of the manubrium, the latter may be said to resemble a three-sided bayonet, one ridge of which passes from the short process directly downward to the tip, and is consequently turned towards the external auditory canal. The point or lower end of the handle of the malleus is flattened into a small disk, one surface of which is turned towards the auditory canal. This spot is plainly visible as the pale, round centre of the umbo.

The long axis of the handle of the hammer is convex posteriorly and inward, so that when viewed from without the manubrium appears concave on its anterior and outer surfaces. This is especially marked at the lower third on the anterior surface, so that the manubrium normally appears curved decidedly forward near its lower end, of course in the plane of the membrana tympani. Along the ridge of the manubrium, directed towards the external auditory canal, several little node-like prominences are not uncommonly seen. These are not pathological, but purely physiological. Their origin is obscure.

Dr. A. H. Buck[1] has described a hook-shaped termination anteriorly, of the manubrium mallei in a boy thirteen years old. The manubrium of the opposite side had been destroyed by otorrhœa, so that it was impossible to make a comparison between the mallei in this case. Wagenhäuser[2] observed in a laborer, forty-two years old, a broad manubrium, presenting in

[1] N. Y. Medical Record, Dec. 16, 1862.

[2] Archiv f. Ohrenheilkunde, Bd. xix. S. 57, 1882.

the lower third a rectangular bend, forward and below. There were no evidences or history of disease in this ear.

Dimensions of the Malleus.—The malleus is nearly 9 mm. long; its manubrium is between 4 and 5 mm. long, and its head is 2½ mm. thick. The latter is the greatest diameter of any part of the bone, which gradually tapers to the point of the handle.

The long diameter of the articulating surface of the malleus is about 3 mm.; the short diameter is between 1½ and 2 mm.

Fixation of the Malleus.—The malleus is held in position by four ligaments, viz.: Ligamentum mallei anterius, ligamentum mallei superius, ligamentum mallei externum, and the ligamentum mallei posterius. The *ligamentum mallei anterius* is a broad band of fibres which holds the processus Folianus against the spina tympanica major. This ligament may be said to arise from the spina tympanica major and to be inserted along the neck of the malleus all the way from the processus Folianus to the head of the malleus. A part of it also runs from the processus Folianus to the short process of the malleus below, and the membrana tympani above, aiding thereby the division between the anterior and posterior pockets of the membrana tympani; another fold of the same ligament runs from the processus Folianus downward with a free margin, as far as the line corresponding with the insertion of the tensor tympani muscle. This aids in making the limiting wall between the anterior pocket of the drum-head and the tympanic cavity.

The round *ligamentum mallei superius* descends obliquely downward and outward from the tegmen tympani to the head of the hammer. Its function is to prevent the malleus from being forced outward.

The *ligamentum mallei externum* is a very important collection of satin-like, tendinous fibres, which radiate from the sigmoid crest on the front of the neck of the hammer and are inserted into the sharp edge of the segment of Rivinus on the temporal bone. It prevents the hammer from being forced inward, and, being inserted above the axis of rotation of the hammer, it prevents the manubrium, which is below the axis of rotation, from moving too far outward towards the auditory canal.

The *ligamentum mallei posticum* is really the posterior edge of the ligament just described as the external ligament of the hammer. As the line followed by this bundle of fibres passes through the spina tympanica major, and as it represents pretty closely the axis of rotation of the hammer, Helmholtz has suggested that it should be considered a separate ligament, and has given to it the name it bears.

As this ligament and the ligamentum anterius are in a mechanical sense one ligament, although the hammer intervenes between them, Helmholtz has called the two sets of fibres the axial ligament of the malleus.

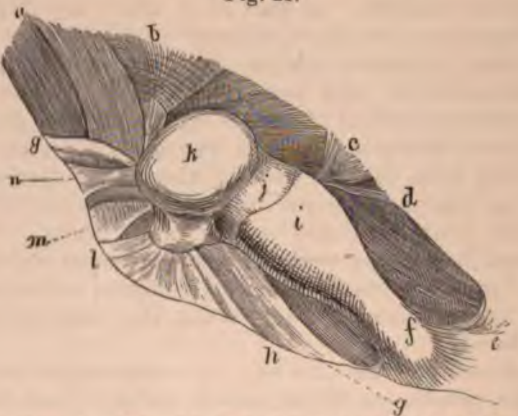
Axial Ligament of the Malleus.—The plane of this ligament is not quite horizontal, being a little higher in front than behind.

In all its motions as a lever the hammer swings about this axis-ligament as a fixed point. All above the short process of the malleus is above, and all below the short process is below, the axis-ligament.

The *ligamentum mallei anterius* of Arnold was once described as a muscle, the laxator tympani major.[1] It is not, however, anything more than a ligament which originates from the spina angularis of the sphenoid, passes through the petro-tympanic fissure,[2] and is inserted into the malleus.

Under the name of *ligamentum mallei posticum seu manubrii*, the *ligamentum mallei externum* of Arnold, Lincke describes a ligament which passes from the upper edge of the end of the external auditory canal to the short process of the malleus, and occupies the position of a supposed muscle, once called the M. laxator tympani minor, or M. mallei exterior seu Casserii. It is now universally acknowledged that muscular fibres do not exist here.[3]

Fig. 21.



Ligamentous Support of Ossicles viewed from above. (Helmholtz.)—*l-h.* Attachment of the ligamentum mallei externum. *k.* Head of hammer. *i.* Body of incus. *f.* Point of its short process. *a.* Entrance to the Eustachian tube from the tympanum. *c.* Stapes. *d.* Tendon of stapedius muscle. *b.* Tendon of the tensor tympani, leaving the cochlear process. *g-g.* Chorda tympani, marking the free edge of the folds of mucous membrane, bounding the pouches. *n.* The upper tendinous fibres of the ligamentum mallei anterius, originating above the spina tympanica major, *m.* *j.* Malleo-incudal joint.

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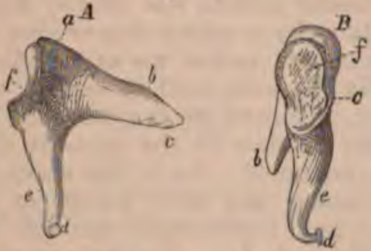
[1] Sömmering.

[2] Glaserian fissure.

[3] Henle, Eingeweidelehre, p. 745.

Incus or Anvil.—The middle one of the three auditory ossicles is the incus or anvil. The name is derived from the shape of its upper half. This small bone is divided into a body and two processes, viz., a short and long one. The former of these two processes is also called the horizontal process. It is held to the posterior and to the upper wall of the tympanic cavity by ligaments.[1] This is an important point in the mechanism of the auditory ossicles.[2] The longer process is also called the descending ramus of the incus. (Fig. 22, *e.*) It curves gradually outward, *i. e.*, towards the external ear, away from the vertical plane of the body of the incus, assuming a slight sigmoid shape; at its tip it curves rather sharply inward, to unite with the head of the stapes by means of the processus lenticularis.

Fig. 22.



RIGHT INCUS. (Magnified 4 diam.: Henle.)—*A.* Inner surface. *B.* View in front. *Aa.* and *Bc.* Body. *b.* Short process. *e.* Long process. *d.* Processus lenticularis. *f.* Articular surface for the head of the malleus. *c.* Surface which lies in contact with wall of tympanic cavity.

The narrowest part of the incus is at the middle of the body of the bone; beneath this part it widens out again anteriorly into the important tooth which locks with the malleus in all its inward movements, and posteriorly into the descending ramus or long process. The articulation between the malleus and incus is a true joint, in which is found a meniscus.[3]

If this articulation is viewed on its outer surface, *i. e.*, on that side towards the external auditory canal, it would seem that the incus quite overlapped or embraced the head of the malleus; when viewed from its tympanic side, however, it appears that the largest share in the joint belongs to the malleus. This is due to the wonderfully peculiar structure of this joint, the true nature and function of which were first pointed out and explained by Helmholtz in 1869.[1]

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[1] Ligamentum incudis posterius et ligamentum incudis superius.

[2] Henle calls this the incus-tympanic joint, "an amphiarthrosis between the articulating surface of the short process of the incus, and a prominence on the posterior wall of the tympanic cavity. The articulating surface on the incus is covered with a thin layer of fibrous cartilage."

[3] Rüdinger.

Dimensions of the Incus.—The greatest length of the incus is in a vertical line passing from the top of the body of the bone through the long process. It measures 7 mm. The horizontal upper edge of the body measures 5 mm. Its greatest thickness, 2½ mm., is at its articulating surface for the malleus.

Malleo-incudal Joint.—Before Helmholtz's investigations, the shape of this articular surface was usually described as resembling a saddle. In order to gain a clearer idea of the mechanism of this joint, Helmholtz makes use of a different comparison. "It is, in fact, like the joint used in certain watch-keys, where the handle cannot be turned in one direction without carrying the steel shell with it, while in the opposite direction it meets with only slight resistance. As in the watch-key, so here, the joint between hammer and anvil admits of a slight rotation about an axis drawn transversely through the head of the hammer toward the end of the short process of the anvil; a pair of cogs oppose the rotation of the manubrium inward, but it can be driven outward without carrying the anvil with it."[2] It is of the kind of joint known as ginglymus. The mechanism of this joint is best understood when it is known that the malleus, as a whole, is a lever, the fulcrum of which passes just below the short process. This, of course, leaves the head and neck, *i. e.*, the articulating surfaces for the malleo-incudal joint and all the free tympanic parts of the malleus, above the line of support of the lever, the manubrium being below. The latter is the long arm of the lever, and consequently all its movements are repeated in an opposite direction on the head of the malleus. Each inward movement of the manubrium, therefore, causes a slight outward motion in the head of the malleus and a firm locking of the malleo-incudal joint, by which the incus is carried about an axis drawn transversely through the head of the hammer toward the end of the horizontal or short process of the incus. The incus being also suspended as a lever, about the line just named, when all above that line moves outward, all below the line moves inward, *i. e.*, as the upper part of the incus is moved outward the long process swings inward and carries the stapes ahead of it, thus forcing the foot-plate of the latter into the oval window.

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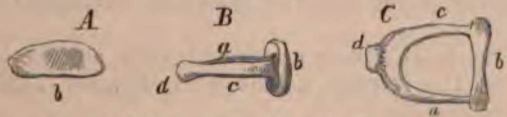
[1] Mechanik der Gehörknöchelchen und des Trommelfells, Bonn; also Pflüger's Archiv f. Physiologie, 1 Jahrgang.

[2] Helmholtz's Mechanism of the Ossicles of the Ear, etc., English translation by Buck and Smith, 1873, p. 33.

The Stapes or Stirrup.—The smallest bone in the body and the innermost of the three auditory ossicles is the stapes or stirrup. Its name is derived from the striking resemblance it bears to a stirrup. It is divided into a head or capitulum, a neck, two branches or legs (crura), and a foot-plate or basis.

The *head*, which is like a cup-shaped button, is placed at the junction of the two crura. It is designed for the reception of the processus lenticularis of the incus, with which it forms a ball-and-socket joint. There is a meniscus in this joint, according to Rüdinger.[1] On the posterior surface of the head of the stapes the stapedius muscle is inserted.

Fig. 23.



Right Stapes. (Magnified 4 diam.: Henle.)—*A*. From within. *B*. From in front. *C*. From beneath. *b*. Foot-plate or base. *d*. Capitulum. *c*. Anterior, *a*, posterior shaft or crus of stapes.

The two *crura* or *branches* are furrowed on their inner surface, which makes them lighter, yet does not deprive them of strength. They arise from the *basis*, forming a graceful arch, and unite above in the *head*, as already stated.

The *foot-plate* of the stapes is oval or slightly kidney-shape, thicker at the periphery than in the centre, is slightly convex towards the vestibule, and concave on its tympanic surface; it fits into the oval window, where it is held by a fibrous packing. This permits of a slight inward and outward movement on the part of the base of the stirrup. When the stapes is in position, the long axis of its base is horizontal and coincides with that of the oval window. In this position its convex edge looks upward, and its concave edge, which gives it its slight kidney-shape, looks downward.

The *ligamentum obturatorium stapedis* is a thin membrane stretching across the space between the base and the crura; it is attached to the crista of the former and the furrow on the inner edges of the latter.[2]

Dimensions of the Stapes.—The stapes measures nearly 4 mm. from its head to the under surface of the foot-plate. The latter is 2½ mm. long in its horizontal diameter, 1 mm. in its vertical diameter (the bone of course must be imagined in normal position), and about ¼ of a millimetre thick, at its edges. It is slightly concave towards its centre.

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[1] Virchow's Archiv, Bd. xx., 1860. Monatsschr. f. Ohrenh., Jan. 1873.

[2] Rüdinger, Atlas of Osseous Anatomy of Human Ear, edited by C. J. Blake, Boston, 1874, p. 9.

Joint Between Base of Stirrup and Oval Window.—According to Helmholtz,[1] the base of the stapes is surrounded at its edge by a lip of fibro-elastic cartilage 0.7 mm. thick. The union between the base of the stirrup and the wall of the labyrinth appears to be formed by means of the periosteum of the vestibule, extended over the base of the stapes (Henle), but the fibrous lip on the edge of the base of the stirrup is not attached to the fenestra ovalis. The mucous membrane of the tympanic cavity extends over the outer or tympanic surface of the base of the stapes.

In 1869, Dr. A. H. Buck examined very closely the fixation of the base of the stirrup in the oval window, and drew the following conclusions:[2]

1. The base of the stapes is fastened to the edge of the oval window by a ligament or elastic fibres. 2. The fibres of the ligament gradually converge towards the edge of the base of the stapes. 3. The ligament arises from the periosteum in the neighborhood of the oval window and passes over to the base of the stirrup, where it again assumes the function of periosteum. 4. The breadth of the ligament is the same all around the periphery of the base of the stapes.

Dr. Gustav Brunner,[3] of Zurich, regards the malleo-incudal and incudo-stapedial joints as a variety of symphysis or synchondrosis. He is disposed to regard the connections between the ossicula auditus not as true or ordinary joints. As described by him, they are all of peculiar construction, since between the cartilaginous surfaces of the bones there is a fibrous or fibro-cartilaginous intermediate substance.

Dr. Rüdinger[4] reasserts the true joint-like structure of the articulations of the ossicula. He also maintains his view that in both the malleo-incudal and incudo-stapedial joint there is a fibro-cartilaginous disk connected with the capsular ligament, but not with the hyaline covering of the articular surfaces of the bones.

Dimensions of the Ossicula Auditus.—Urbantschitsch,[5] by comparing the auditory ossicles of 50 different tympana, found that the *malleus* varied in length from 7.0 to 9.2 mm.; the average length is 8.5 mm. The *short process* varies from 1.2 to 2.6 mm., with an average length of 1.6 mm. The *long process* (the Folian process) was found in one case, an individual 30 years old, to be 2.5 mm., and in another, a man 20 years old, 5.8 mm. long. The *manubrium* has an average length of 5.0 mm. from the short process to the point.

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[1] Op. cit., pp. 34–35.

[2] Archiv f. Oph. and Otol., 1 Band, Carlsruhe, 1870.

[3] Ueber die Verbindung der Gehörknöchelchen, namentlich, des Hammer-Ambossgelenks, Vorläufige Mittheilung. M. f. O., No. 1, 1872.

[4] Ueber die Gelenke der Gehörknöchelchen, M. f. O., No. 3, 1872.

[5] Archiv für Ohrenheilkunde, Band xi. pp. 1–11.

In the *incus*, the distance of the upper end of the articular surface from the free end of the horizontal ramus is, on the average, 5.3 mm. The under end of the surface of the joint is 4.6 mm. distant from the incudo-stapedial joint. The incus is the most porous of the ossicles. The average length of the *stapes* is 3.7 mm.; its average breadth between the rami, 2.3 mm. Its head is either entirely straight (29 times), or else inclined towards the anterior (18 times) or posterior limb (3 times); in one case the head pointed upward, *i. e.* towards the upper edge of the foot-plate of the stapes. The entire paper of Dr. Urbantschitsch will amply repay a careful reading.

According to the investigations of Dr. C. J. Blake,[1] the weight of the ossicula auditus varies greatly with the age and individual. It is also worthy of note that the proportionate weight of the ossicula, one to another, is not constant. Dr. Blake states that in the new-born child, the proportionate weight of the malleus to the incus is generally as 20 to 17, and in a malleus weighing 20 milligrammes, the weight would be distributed as follows: "the capitulum mallei, including that portion of the neck just above the processus brevis, 16 milligrammes; the processus longus, including the processus brevis, 4 milligrammes."

"In an incus weighing 17 milligrammes, the corpus incudis, including the processus brevis and the base of the processus longus as far downward as the lower lip of the inferior articulating surface, 14 milligrammes; and the processus longus, with the os lenticulare attached, 3 milligrammes, the corresponding stapes weighing very nearly 4 milligrammes. In the adult, the weights of the malleus and incus are, as a rule, more nearly equal; in some cases, however, the proportionate weight of the malleus to the incus is as 7 to 8."

The distribution of weight above and below the axial line—the line about which the malleus tends to swing (see p. 70)—is as follows, according to the investigations of Dr. Blake: In a malleus which weighed 21 milligrammes, and the incus 25 milligrammes, the combined weight of the portions of these two bones, above the axial line, the line of section in the experiments, was 30 mg.; that below the line, 16 mg., or in the proportion of 15 to 8. This preponderance of weight in the parts of the malleus and incus above the axial line, tends to act as a mechanical counterbalance, and renders the two bones better able to vibrate upon the axial line. It also serves to increase the delicacy of a mechanism which responds to sound-waves in excursions so infinitesimal that the highest powers of the microscope cannot render them visible, as declared by Helmholtz.

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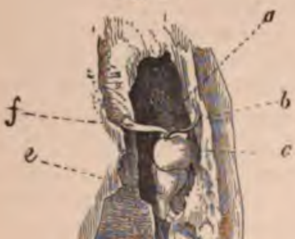
[1] Distribution of Weight in the Ossicula Auditus. Transactions Amer. Otol. Soc., vol. i. p. 543.

The Tympanum.—The tympanic cavity is about half an inch in height and width, and a line or two deep, measuring from within outward. It is lined with mucous membrane, which is reflected over all the tympanic contents, and is a continuation of that of the throat, nose, and Eustachian tube. The drum cavity lies entirely within the temporal bone, and is bounded by a roof and floor, and the four walls.

The *roof*, or tegmen tympani, is the boundary between the base of the brain and the tympanum. This osseous partition is very thin, and in some cases congenital fissures in it persist; in such instances the only boundary at the dehiscences, between the tympanum and the cerebral cavity, is formed by the mucous membrane of the former and the membranes of the brain. It is evident that in such cases pathological processes in the drum-cavity are especially liable to pass upward to the brain.

Fig. 24.

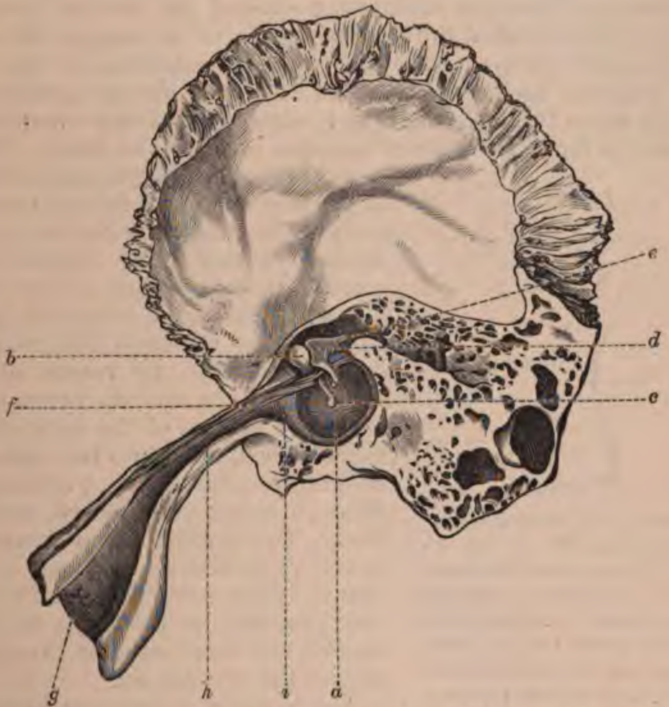


Right Tympanic Cavity viewed from above; Malleo-incudal and Incudo-tympanic Joints. (Magnified 2 diam.: Henle.)—*c*. Head of malleus. *e*. Short process of incus. *f*. Tendon of tensor tympani muscle. *d*. Capsule of incudo-tympanic joint. *a*. Ligamentum mallei anterius. *b*. Chorda tympani.

The Malleo-incudal joint and surrounding parts viewed from above.—If the tegmen tympani be removed, let us say, from the *right* tympanic cavity, the malleo-incudal joint and the incudo-tympanic joint will be laid bare, and just in front of the head of the malleus, but below it, will be seen the tendon of the tensor tympani muscle coming upward and inward from the left, to be inserted into the tubercle on the neck of the hammer. Above this tendon, winding from within outward and to the right, around the neck of the malleus, is seen the chorda tympani on its way to the Glaserian fissure. Of course, this picture is to be reversed for the left ear. The suspensory ligament of the malleus is attached to the roof of the tympanic cavity.

The Floor of the Tympanum.—The floor of the tympanum is not much more than a groove between the outer and inner wall. It is below the lower periphery of the drum-head, the opening of the Eustachian tube, and the opening in the mastoid cells. It is entirely within the boundary of the petrous portion of the temporal bone and above the jugular fossa.

Fig. 25.

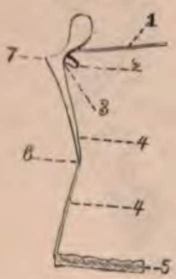


VERTICAL SECTION OF THE RIGHT EUSTACHIAN TUBE, TYMPANIC CAVITY, AND MASTOID CELLS, WITH INNER SURFACE OF THE SQUAMA ABOVE VIEWED FROM WITHIN.—*a*. Membrana tympani. *b*. Head of malleus. *c*. End of the manubrium mallei. *d*. Incus. *e*. Short process of incus. *f*. Tensor tympani muscle. *g*. Faucial opening of the Eustachian tube. *h*. Isthmus tubæ. *i*. Tympanic mouth of Eustachian tube.

The Outer Wall of the Tympanum.—The outer wall of the tympanic cavity is composed mainly of the membrana tympani. The bony framework of the annulus tympanicus around the membrana tympani, constitutes the limit of the outer wall of the tympanum. In connection with the outer wall, *i. e.*, in it or on it, we find the manubrium mallei, the chorda tympani, and the duplicature of mucous membrane about it, which also forms the inner boundary of the so-called pockets of the membrana tympani.

The pockets or pouches of the membrana tympani are the spaces lying between the upper part of the membrana tympani and the duplicature of mucous membrane around the chorda tympani nerve, in the so-called horizontal portion of its passage through the tympanic cavity. After the mucous membrane of the tegmen tympani has been reflected over the chorda tympani, it ascends again to reach the upper edge of the drum-membrane, in order to form the inner or mucous layer of the latter. Thus it is that the chorda tympani is found at the free edge of a fold of mucous membrane, which, with the membrana tympani lying further outward, forms a space or pocket open below. This space or groove lying between the aforesaid fold and the drum-membrane, by reason of the clinging of the chorda tympani to the inner surface of the neck of the malleus, is divided into two spaces—an anterior, the smaller, and a posterior, a larger one—called, respectively, the anterior and posterior pouch or pocket of the drum-membrane. They were first described by von Troeltsch, in 1856, and are situated on the inner edge of the upper part of the drum-head.

Fig. 26.



Diagrammatic representation of the Formation of the so-called Pouches of the Membrana Tympani.—1. Mucous membrane of tegmen tympani. 2. Reflection of same over chorda tympani nerve. 3. A pouch of the membrana tympani. 4, 4. Inner surface of membrana tympani. 5. Section through osseous floor of tympanic cavity. 6. Umbo of the membrana tympani. 7. Short process of malleus.

The *posterior* pouch lies between the malleus and the posterior periphery of the membrana tympani, and is the larger of the two. Von Troeltsch claims that it contains in its structure traces of the fibrous layer of the drum-head, but this is denied by Gruber and Bochdaleck.[1] The shape of the posterior pouch is triangular or tent-like, the apex of which is directed inward, and its base outward. It is about 3 mm. high, and 4 mm. broad. This pouch is best seen when the inner side of the drum-head is viewed, but it can also be seen from the outer side, when the drum-head is thin and properly illuminated.

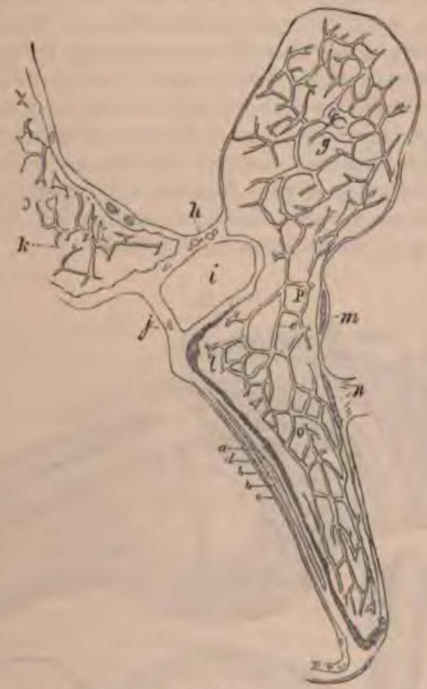
The *anterior* pouch lies in front of the malleus, and is smaller than the posterior pouch. Its inner wall is composed of mucous membrane only. It is not so well marked as that of the pos-

[1] Gruber's Lehrbuch, p. 88.

terior pouch, but contains "all the parts which proceed from or enter the Glaserian fissure." The anterior is much lower and shorter than the posterior pouch.

There is a third pocket or pouch of the membrana tympani described by Prussak[1] and Gustav Brunner.[2] (Fig. 27, *i.*) This cavity is bounded behind by the neck of the malleus, below by the upper surface of the short process of the hammer, in front by the membrana flaccida, and above by a ligamentous band, the ligamentum mallei externum, which is inserted between the

Fig. 27.



Section through the long Axis of the Malleus at right angles to the Membrana Tympani, from an Adult. (Brunner.) *k.* Bony ridge at the upper segment of the drumhead. (The segment of Rivinus, according to Helmholtz.) *g.* Head of malleus. *p.* Neck of malleus. *o.* Handle of malleus. *l.* Short process. *j.* Membrana flaccida. *h.* Lig. mallei externum. *m.* Chorda tympani. *n.* Tendon of tensor tympani. *i.* A cavity according to Prussak. *a.* Cartilage. *b, b.* Fibres of the membrana tympani. *c.* Dermoid layer of membrana tympani. *e.* Haversian canals. *f.* Medullary space.

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[1] Archiv für Ohrenheilkunde, vol. iii.

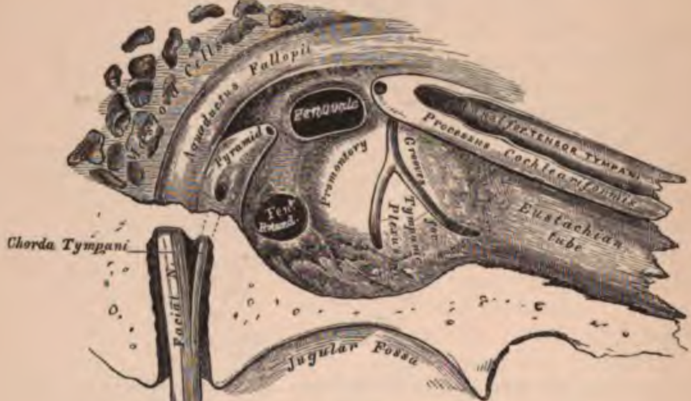
[2] The Connections between the Ossicles of Hearing. Archives of Oph. and Otol., vol. iii. pp. 145–172, 1874.

margo tympanica and the spina mallei. This cavity is separated from the anterior tympanic pouch by the upper blind end of the latter; posteriorly, it communicates with the tympanic cavity by a good-sized opening, above the position of the posterior tympanic pouch. This pouch, being thus placed in communication with the tympanum, may become filled with mucus or pus, and it may, in consequence, be ruptured.

Many cases of earache, which present no features of distention of the drum-head proper, nor, in fact, of the region of the membrana flaccida, may be relieved instantly by puncturing the latter at the third pouch. The point of the puncturing in such cases is just above and in front of the short process.

As a general rule, when there is severe earache, attended only by redness of the flaccid part of the drum-head, and neither congestion nor bulging of the drum-head proper, a cut into the congested flaccid part will relieve the suffering. Mucus or pus will usually escape; sometimes only blood.

Fig. 28.



INNER WALL OF TYMPANIC CAVITY. (Gray.)

Inner Wall of Tympanum.—On the inner wall of the tympanic cavity there is found a convexity, the promontory caused by the projection outward at that point of the lower turn of the cochlea. This eminence is usually seen through the membrana tympani, as a pale yellowish spot. At this point the inner and outer walls of the tympanum are closest to each other. Above the promontory, in a depression named the *fossula fenestræ ovalis* (Rüdinger), is the oval window, *fenestra ovalis*, which receives the foot-plate of the stapes. Behind the promontory is the niche in which is found the round window, *fenestra rotunda.* The long diameter of the oval window is 3 mm., and its short diameter 1.7 mm. The diameter of the round window is 2 mm. A ridge starts above the oval window and curves backward and downward behind the promontory and round window. This ridge is the posterior limit of the inner wall of the tympanum, and marks the position of the canal for the facial nerve, which escapes from the tympanum at the stylo-mastoid foramen. The course of the facial nerve will be considered further on.

Eminentia Stapedii.—Behind, and a little below the line of the oval window, is a bony eminence, the *eminentia stapedii.* This little conical eminence is hollow and contains the stapedius muscle, to which it gives origin. The tendon of this muscle, after passing through a small opening in the apex of the eminence, runs a little upward and forward, forming an obtuse angle with the long axis of the muscle, and is then inserted into the edge of the articular surface of the head of the stapes.[1] The stapedius muscle is supplied with a branch from the facial nerve.

Function of the Stapedius Muscle.—According to Henle,[2] it is probable that the stapedius muscle serves to hold the stapes in a firm position rather than to move it, and that it acts only when there is danger that an undue force communicated to the malleus will be conveyed to the stapes by means of the intervening incus. Its action then is to prevent the stapes from being forced into the oval window, and also to antagonize the tensor tympani muscle.

Fixator Baseos Stapedis.—Rüdinger has described an organic muscular structure on the tympanic surface of the stapes, which he calls the *fixator baseos stapedis.* It arises from a small bony ridge (diameter 0.8 mm.) situate one millimetre from the upper and posterior circumference of the oval window, and is inserted into the angle formed by the leg of the stapes and its somewhat projecting foot-plate. It is supposed to be an antagonist of the voluntary muscle, the stapedius.[3]

Topographical Relation of the Stapedius Muscle to the Facial Nerve.—In the fœtus only the upper part of the stapedial cavity is separated from the facial canal by bone, the lower part having free communication with the canal.[4] At this point the soft tissues surrounding the muscle and the nerve are in contact. In the adult, however, the communication between the bony cavity containing the muscle and the facial canal is less free, being effected by means of one or more small openings or by one long, slit-like aperture 3–5 mm. long, and ½ mm. wide. Transverse sections of this muscle show that it is a triangular prism; longitudinal sections show that its general form is pear-shaped.

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[1] Henle.

[2] Eingeweidelehre, p. 749.

[3] Das häutige Labyrinth, by Rüdinger, Stricker's Handbuch, pp. 912–913, 1872.

[4] Prof. Politzer, Zur Anatomie des Gehörorgans, I. Ueber das Verhältniss des Musc. Stapedius zum nervus facialis, II. Ueber den Processus Styloideus, Archiv f. Ohrenh., ix. p. 158.

In addition to the anatomy, Prof. Politzer has added to the knowledge of the physiology of the stapedius muscle. He shows that this muscle acts as a laxator of the membrana tympani, and, as far its effects upon the labyrinth are concerned, it diminishes the pressure in that cavity by drawing the stapes out of the oval window.[1] The oval window is separated from the round window by the tract of bone corresponding to the posterior surface of the promontory. They are about two millimetres apart. The plane of the former looks outward, and is nearly vertical in its position; that of the latter looks backward and downward. The oval window is the entrance to the vestibule and mediately to the cochlea. The round window is an exit from the cochlea into the tympanic cavity. This window, however, in its normal state, is hermetically closed by a membrané, the membrana tympani secundaria, or membrana fenestræ rotundæ.

Well forward, on the inner wall, towards the tympanic opening of the Eustachian tube, are the *processus cochleariformis*, the spoon-shaped tympanic end of the *septum tubæ*, which separates the Eustachian tube from the bony furrow containing the tensor tympani muscle, and the tendon of the latter as it passes to the malleus. The *processus cochleariformis* is the fulcrum over which the tendon of the tensor tympani plays.

Tensor Tympani Muscle.—This muscle originates from the anterior mouth of the *canalis musculo-tubarius* of the pyramidal portion of the temporal bone, the upper wall of the cartilage of the Eustachian tube, and from that small portion of the sphenoid bone which joins the temporal bone, the processus angularis. The muscle then passes over the *septum tubæ* and enters the semi-canalis tensoris tympani.[2] Its tendon passes over the processus cochleariformis, and, turning outward, crosses the tympanic cavity at right angles to the belly of the muscle, to be inserted into the malleus. The tensor tympani is connected with the dilatator tubæ or tensor palati, by both tendinous and muscular fibres, as shown by Kessel, Rüdinger, Mayer, Rebsamen, and others. The motor nerve of the tensor tympani is derived through the otic ganglion[1] from the motor root of the trigeminus.[2]

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[1] Loc. cit., p. 162.

[2] This canal is not always perfectly closed, and hence it has been called the semi-canalis tensoris tympani.

The tensor tympani muscle has been described as a penniform muscle,[3] in allusion to its appearance, which is due to the fact that the muscular fibres arise from the periosteum of the upper wall of the bony canal in which the muscle lies, and pass into the tendon which lies on the under edge of the muscle; the latter is turned towards the floor of the canal. As the fibres of the muscle are short, a large portion of the tendon is within the canal, where the muscle is covered by a periosteal sheath, which is continued over the free portion of the tendon, crossing the tympanic cavity, and is there covered with mucous membrane. This sheath of the free tympanic part of the ligament, Toynbee called *the tensor ligament of the membrana tympani.* Helmholtz has found that in some cases the ligament is movable within this sheath, as described by Toynbee; on the other hand, Henle has never found them entirely separate, nor differing from similar fibrous structures of other tendons. In any event, the play of the tendon within the sheath cannot be very great, on account of the slight motions of the malleus, as shown by Helmholtz.

The transverse section of a perfect tensor tympani muscle measures 2.75 mm., the length of its tendon from the processus cochleariformis to the insertion into the malleus is 2.25 mm., and the length of the muscle from its extreme origin in the Eustachian tube to the turn of the processus cochleariformis is 2.2 centimetres, somewhat more than an inch, as shown by Weber-Liel. The tendon of the tensor tympani is inserted on the anterior surface of the inner edge of the manubrium, rather than on its posterior surface; hence, traction inward of the muscle will cause a rotation of the malleus about its long vertical axis, and thus twist the posterior surface of the handle of the malleus outward, and with it the posterior segment of the membrana tympani. It therefore often seems, in certain pathological retractions of the malleus, that the anterior segment of the membrana tympani is sunken, and that the anterior outline of the manubrium is especially prominent.

Anterior and Posterior Walls of the Tympanic Cavity.—The most important point in the *anterior* wall is the tympanic opening of the Eustachian tube, situated considerably above the floor of the tympanum, an arrangement which often produces a retention of small amounts of fluid in the cavity.

It remains to consider, now, the *posterior* wall of the tympanic cavity, in which is situated the important opening communicating with the mastoid antrum, and by that means with the mastoid cells. The *mastoid antrum* is a cavity of irregular shape, the roof of which is a continuation backward of the tegmen tympani. It is formed by a hollowing out of the basis of the pyramidal part of the temporal bone, which is joined to the mastoid portion at the upper part of the latter. This cavity may extend forward into the root of the zygomatic arch and downward into the mastoid cells. It communicates with the tympanum by means of a wide opening, the under edge of which is about on a level with the oval window. The floor of the tympanic cavity rises backward to meet this opening, in the same way as it rises anteriorly to the opening for the Eustachian tube.

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[1] Henle, Eingeweidelehre, p. 747.
[2] Ludwig and Politzer, Meissner's Jahresbericht, 1860, p. 583.
[3] Helmholtz.

Course of the Facial Nerve.—Although the *canalis facialis* has been already mentioned in connection with the inner wall of the tympanum, further attention should be given at this point to the course of the facial nerve, and the important relations it sustains to the structures in the posterior portion of the tympanum and to the mastoid cells.

The *facial canal* rises at the fundus of the internal auditory canal, and after leaving it, it passes somewhat in front of and further outward than it, between the cochlea and the semicircular canals, above the roof of the vestibule. Upon reaching the plane of the inner wall of the tympanic cavity, it turns[1] suddenly backward at right angles to its former course, and, running above the position of the oval window, curves gradually backward and downward, to escape from the tympanic cavity at the stylo-mastoid foramen in the postero-exterior surface of the petrous bone. In the anterior wall of the facial canal, very near the stylo-mastoid opening, is a small foramen leading to the *canalis chordæ*, which, leaving the facial canal, runs upward and forward through the substance of the petrous bone to the tympanum, in the lower external corner of which it opens. (Fig. 28.)

Development of the Bony Canals in and about the Tympanic Cavity.—1. Carotid canal. The carotid canal is the simplest in structure and formation of the canals in or about the tympanum.[2] It appears about the third or fourth month of fœtal life, as a simple furrow on the inner side of the blunt point of the petrous part of the temporal bone. By the end of the fourth month a bony ridge rises out of the furrow on the tympanic side and pushes its way between the cerebral carotid and the tympanum, thus forming a bony partition between them. Another osseous ridge grows from below upward and joins this first ridge, forming with it, by the ninth fœtal month, the complete carotid canal.

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[1] *Genu canalis facialis*, at which point the canal for the great superficial petrosal nerve joins the facial canal. (Henle.)

[2] Prof. Rüdinger, Monatsschr. f. Ohrenh., No. 5, 1873.

2. Fallopian canal. This canal, too, appears at first as a simple broad groove in the tympanum. About the third month of fœtal life this canal begins to form by the gradual growth of thin bony lamellæ. The eminentia stapedii forms as a branch-like projection from the facial canal. The formation of the Fallopian canal is not complete until after birth. Dr. Rüdinger also describes a constant opening in that part of the facial canal over the oval window. This would seem to correspond to that one described by Dr. Zuckerkandl as the point of entrance of the stapedial artery into the tympanic cavity. The history of the development of the canaliculus chordæ, the canaliculus tympanicus and mastoideus Arnoldi, and the bony portion of the Eustachian tube and semicanal of the tensor tympani is, in many respects, according to Rüdinger, similar to the above.

Lymphatic Cavity in the Facial Canal.—On the inner side of the facial canal, Dr. Rüdinger[1] has described an empty space lying between the nerve trunk and the periosteum. This cavity or cleft, as it would appear in a transverse microscopical section, presented a sharp definition, and appeared as a constant occurrence in every individual case examined. The supposition is that this space marks an extension of the arachnoidal sac of the brain, into the canal of the facial nerve, and is similar to that which is known to accompany both the optic and the acoustic nerve; it may therefore be regarded as a lymph cavity.

Chorda Tympani Nerve.—The chorda tympani has always been described as a branch of the facial nerve, though there is much to lead to doubt that it has such an origin. The investigations of H. R. Bigelow and Sapolini, respecting the chorda tympani, will be given further on. After its entrance into the tympanic cavity it becomes invested with mucous membrane, and, ascending into the cavity, follows quite closely the posterior periphery of the membrana tympani until it reaches the height of the tendon of the tensor tympani, when it winds forward, above this tendon, between the malleus and incus, and finally escapes from the tympanic cavity at the Glaserian fissure, through the canal of Huguier. It then descends between the two pterygoid muscles, to unite with the gustatory nerve, and is finally distributed with it to the submaxillary gland; it then joins the submaxillary ganglion and terminates in the lingualis muscle, as shown by Gray. This nerve has very little sensibility according to Vulpian,[1] whose experiments have shown that the chorda tympani contains both centrifugal and centripetal fibres, the latter serving as a means of excito-motory irritation, destined to act on the sublingual gland. According to Vulpian, and Prevost, of Geneva, part of the chorda tympani accompanies the lingual nerve in its peripheric distribution, furnishing branches to all the terminal filaments of the latter.

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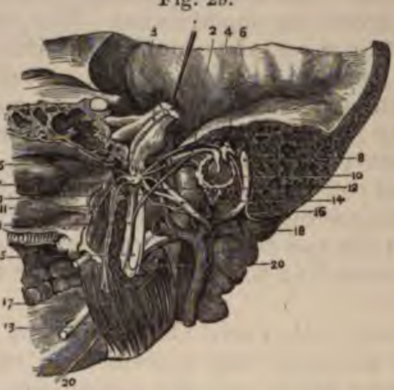
[1] Ueber den canalis facialis in seiner Beziehung, zum siebenten Gehirnnerven beim Erwachsenen, M. f. O., 1873, No. 6.

Fig. 29.



Nerves in and about the Tympanum. (Heath.)—1. Sensory portion of the fifth nerve with Gasserian ganglion. 2. Tensor tympani muscle. 3. Motor portion of the fifth nerve passing beneath the ganglion. 4. Malleus. 5. Small superficial petrosal nerves of Arnold. 6. Incus. 7. Otic ganglion. 8. Facial nerve. 9. Chorda tympani. 10. Membrana tympani. 11. Tensor palati muscle. 12. Middle meningeal artery. 13, 13. Lingual nerve. 14. Auriculo-temporal nerve. 15. Inferior dental nerve. 16. Pterygoideus externus. 17. Pterygoideus internus. 18. Internal maxillary artery. 20, 20. Mylohyoid nerve.

Since the publication of the first edition of this treatise the following conclusions respecting the chorda tympani nerve have been made by Dr. H. R. Bigelow:[2]

1. The chorda tympani nerve is distinct and integral throughout its entire length, and *not* a branch of the facial. 2. It is derived from the nerve of Wrisberg. 3. Its special *sensory* function is derived from the ganglion upon the nerve of Wrisberg, into the granular protoplasm of which the ultimate fibrils may be traced. It is further concluded that this nerve is a carrier of the sense of taste from the cells in the intumescentia gangliformis.

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[1] Gazette Médicale de Paris, Feb. 15, 1873.

[2] Archives of Medicine, June, 1879. N. Y. Med. Record, Jan. 17, 1880.

Sapolini's[1] conclusions, based upon personal investigation of the chorda tympani, are both novel and important. He believes it to be an independent, a thirteenth cranial nerve, and claims that the nerve discovered by Eustachius and Wrisberg is a part of the chorda tympani, which takes its origin from the floor of the fourth ventricle, and terminates in the muscles of the tongue. The dissection was begun at the calamus scriptorius, and carried to the ganglion geniculatum, in the genu of the facial canal. It is claimed that there exists a nerve lying close to it, but entirely separate from the facial nerve at this point. This investigator then proceeded to dissect the chorda tympani, from the tympanum backward to the aforesaid ganglion geniculatum, and found that the chorda tympani is one and the same nerve as the intermediary nerve of Wrisberg, which he had already traced from the brain to the geniculate ganglion.

The chorda tympani can be easily dissected from the tympanum, through the canal of Huguier, in the Glaserian region, to its junction with the lingual branch of the fifth nerve. From this point of anastomosis, Sapolini has found that the chorda tympani forms a dense plexus with the lingual nerve, distributed to the muscles of the tongue, and for this plexus he proposes the name of "plexus tympano-lingualis." Since this nerve originates from the corpora restiformia and the lateral cords, it is supposed to contain both sensitive and motor fibres. There are, however, more filaments of this nerve than of the lingual nerve distributed to the muscles of the tongue. The latter nerve supplies chiefly the superficial tissues of the tongue. Sapolini concludes, therefore, from the large number of fibres of the chorda tympani thus distributed to the muscles of the tongue, that it is the special nerve of speech. His theory is that a vowel cannot be formed without a special movement of the tongue, and in no way can consonants be accented without special and simultaneous contraction of one or more intrinsic muscles of the tongue, and it is held that the chorda tympani presides over this function.

When a child begins to articulate, the monosyllable or the word which it attempts to pronounce, begins with the vowel *a* or *o*, which requires the least motion of the tongue. The slow progress in articulation seems to correspond with the late appearance of white nerve fibres, which subsequently appear on the floor of the fourth ventricle.

Nerves supplying the Mucous Membrane of the Tympanic Cavity.—The nerves supplying the mucous membrane of the tympanic cavity as well as that of the Eustachian tube and mastoid cells, are derived from the tympanic nerve, also called the tympanic plexus, an anastomosis between the otic ganglion, petrosal

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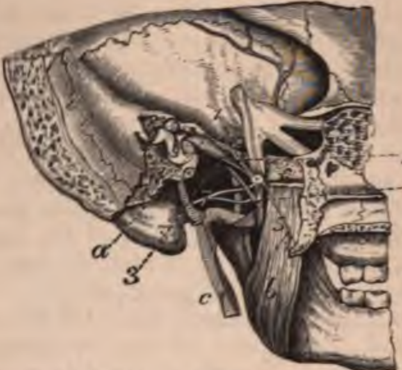
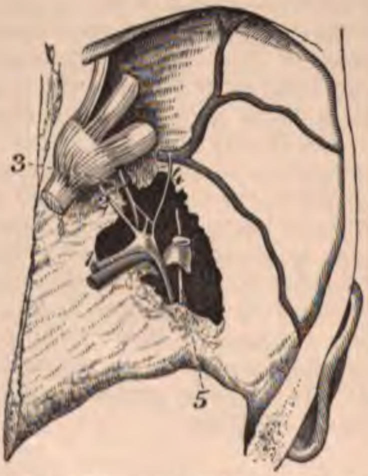
[1] Un Tredicesimo nervo craniale (thirteenth cranial nerve), Milan, 1881. See review by Vermyne, American Journal of Otology, 1881, pp. 312–322.

Fig. 30.



VIEW OF OTIC GANGLION. (Ellis.)—*a.* Tensor tympani muscle. *b.* Internal pterygoid muscle, with its nerve entering it. *c.* External carotid artery, with the sympathetic on it. 1. Otic ganglion. 2. Branch of Jacobson's nerve. 3. Nerve to tensor tympani. 4. Chorda tympani joining gustatory nerve. 5. Nerve to pterygoideus internus. 6. Nerve to tensor palati. 7. Auriculo-temporal nerve.

Fig. 31.



NERVES JOINING THE ENLARGEMENT OF THE FACIAL NERVE, RIGHT SIDE. (Ellis.)—1. Facial nerve. 2. Large superficial petrosal. 3. Small superficial petrosal. 4. External superficial petrosal. 5. Chorda tympani nerve.

ganglion of the glosso-pharyngeal nerve, and the carotid plexus, by means of the superior cervical ganglion of the sympathetic nerve.[1] Wolf[2] and Blau[3] claim to show that the chorda tympani contains both sensory and gustatory fibres.

The *otic ganglion* is situated on the inner side of the sensory division of the inferior maxillary nerve, and sends several small branches to it. From the otic ganglion emanates also the small petrosal nerve which joins the facial nerve and the tympanic branch of the glosso-pharyngeal nerve. The tympanic nerve, furthermore, sends branches which anastomose with the smaller and greater petrosal nerves. The latter branch is also in connection with Meckel's ganglion. The external petrosal nerve is in connection with the sympathetic nerve on the middle meningeal artery. (Fig. 31.) It is important to bear these relations in mind when considering certain neuralgias in and about the ear, which might otherwise prove very puzzling.

Numerous cases of earache are constantly seen, which are solely and clearly due to imperfect teeth. This may be explained by the fact that by means of the otic ganglion, the soft palate, the drum-head, and tensor tympani muscle, the lining membrane of the cavity of the tympanum, the integument of the external ear, and the teeth, are put in sympathetic relation with one another.

Perhaps certain epileptiform phenomena which have been observed in connection with well-marked disease of the middle ear, as well as similar phenomena which could be seen to be connected with disease of the external ear, may be explained by reflex communication through the tympanic plexus.

The *tympanic nerve* or *Jacobson's nerve* is a branch from the petrosal ganglion[4] of the glosso-pharyngeal nerve; "it enters a small bony canal on the base of the petrous portion of the temporal bone, ascends to the tympanum, enters this cavity by an aperture in its floor close to the inner wall, and divides into three branches, which are contained in grooves upon the surface of the promontory."[5] This is the largest nerve branch given to the tympanic cavity, and therefore it has received its special name and consideration from most anatomists. Since, however, the tympanic nerve contains so large a number of large ganglion cells, either solitary or grouped, and thus makes numerous connections with other important ganglia and nerves, the name *tympanic plexus* is now given to what formerly was named, in its tympanic portion at least, the tympanic nerve.

Bloodvessels of the Tympanic Cavity.—The chief artery of the tympanic cavity runs along the floor of the tympanum and over the promontory.

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[1] Bischoff, Microscopische Analyse der Kopfnerven, München, 1865.

[2] Archiv f. Ohrenh., Bd. 16, 1880, p. 299.

[3] Ibid., p. 145.

[4] Andersch.

[5] Gray.

According to Gray, the arteries supplying the tympanic cavity are as follows: The *tympanic branch* of the *inferior maxillary* which is given to the *membrana tympani*, the *stylo-mastoid* branch of the *posterior auricular*, distributed to the back part of the *tympanic cavity* and *mastoid cells*, a number of smaller branches from the *petrosal* branch of the *middle meningeal*, and branches from the ascending pharyngeal and internal carotid. The *veins* of the tympanic cavity terminate in the *middle meningeal* and *pharyngeal veins*, which form a plexus near the glenoid articulation, and then empty into the *internal jugular vein*. It is very important to bear in mind these distributions of bloodvessels, when the ear is to be leeched.

Dr. Zuckerkandl[1] has described as constant, an artery which he has termed the arteria stapedia. This artery is a branch of the stylo-mastoid artery, which enters the tympanum through an ever-present triangular opening in that part of the facial canal passing just above the fenestra ovalis. This small vessel descends through the membrana obturatoria of the stapes, either to anastomose with a branch of the artery following Jacobson's nerve, or to break up into secondary anastomoses before it reaches this point. Before the artery passes the stapes it gives off a branch to the anterior crus of the stapes and to the anterior part of the membrana stapedia which it divides in two, a second branch to the hinder crus and to the posterior part of the stapedial membrane, and a third arteriole usually from one of the lateral branches passes inward to the foot-plate of the stapes.

PHYSIOLOGY.

The function of the tensor tympani muscle is somewhat like that of the palmaris,[2] *i. e.*, it is better adapted for tension than for motion. It also appears that, by exerting a slight tension on the membrana tympani, this muscle can bring about a muffling or damping effect without any visible movements in the ossicles.

In 1860, Politzer[3] showed that the tensor tympani was supplied by a branch of the motor division of the fifth nerve.

Later, Voltolini[4] performed a series of experiments which led him to the following conclusions:

"1. Irritation (by electricity) of the trigeminus produces distinct and powerful contractions of the tensor tympani, which can be kept up for some time on the dead animal; these contractions can almost always be produced even by weak streams of electricity.

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[1] Ueber die Arteria Stapedia des Menschen, Monatsschr. f. O., No. 1, 1873.

[2] Henle, op. cit. p. 748.

[3] Meissner's Jahresbericht, p. 583.

[4] Virchow's Archiv, Band 65, p. 467.

"2. The same result can be obtained by irritation of the facialis, but usually only by strong electric currents, and the irritability is generally soon lost.

"3. During this contraction of the tensor, the drum-head is drawn strongly inward by means of the manubrium, but, of course, these excursions of the drum-head vary in different animals; in guinea-pigs they are so small as to be undistinguishable unless an indicator is attached to the membrane.

"4. During such a contraction of the tensor and the consequent tension of the membrana tympani, a simultaneous ascent of the lymph in an opened semicircular canal becomes visible in the dead animal, and when the tension is removed the fluid sinks back.

"5. In no instance, neither by excitation of the trigeminus, nor of the facial nerve, nor even by mechanical movement of the stirrup, was a simultaneous movement in the membrana tympani secundaria visible, not even by microscopic observation of a reflection, or an indicator attached to the membrane.

"6. During irritation of the trigeminus, and the consequent contraction of the tensor tympani, there ensues a contraction of the palatal muscles and an opening of the Eustachian tube, for the anterior membranous wall is drawn away from the posterior cartilaginous tubal ridge."

The fact that the tensor tympani can be put into motion by excitation of two cerebral nerves, as above stated, may, according to Voltolini, be used as an explanation of the power the muscle has of both voluntary and involuntary movement.

In one of his experiments, Voltolini observed that excitation of the facial nerve produced contractions in the tensor tympani and stapedius muscle. Such a process, says the observer, is of highest importance in the act of hearing, if, indeed, such a process occur in the living ear, which is not to be doubted; in such an event the stapedius muscle acts as a check on the movement of the hammer by the tensor tympani.[1] The reflex movements of the tensor may be accounted for by the branch of the trigeminus which passes through the otic ganglion.

Then arises, as Voltolini suggests, the important question whether the fibre from the facial nerve, supplying the tensor, also passes through the otic ganglion, or goes directly from the facial to the muscle; in the latter case the muscle would evidently possess power of voluntary motion. Although no one has demonstrated that a branch of the facial nerve does pass directly to the tensor tympani, the muscle certainly possesses power of voluntary contraction, as held by Johannes Müller, Voltolini, and others.

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[1] Loc. cit., p. 479.

In this connection, it must not be forgotten that the tensor tympani muscle is closely related to the muscular structures of the Eustachian tube. The latter obtains innervation from the glosso-pharyngeal nerve, and by this means also, the tensor tympani muscle may obtain some of its nerve-supply from this sensori-motor nerve.

Physiological Nature of Certain Tympanic Bands, heretofore considered Pathological.—Dr. Victor Urbantschitsch[1] has pointed out the physiological nature of certain membranous and cord-like adhesions in the cavity of the tympanum, which have heretofore been considered pathological. As he states, Prof. Politzer was the first to express the opinion that such might be the case, and the former has verified this opinion by a series of careful and copious investigations on the cadavers of embryos, new-born children, and adults. He has frequently found, in the new-born child, membranous and cord-like connections between the inner side of the vertical shaft of the incus and the inner wall of the tympanum. This has been considered pathological by Toynbee and other authors; but Urbantschitsch has shown that these formations are remnants of an embryonic fold, running from the vertical ramus of the incus to the inner wall of the tympanum, entirely inclosing the stapes. This was seen eight times in embryos, fifty times in the new-born child, and sixteen times in fifty examinations of the tympanic cavity in the adult.

There is also an embryonal stapedial fold which sometimes leaves as residue small membranes or cords passing from the head and shafts of the stapes. But this observer does not assert that all of the connecting bands or membranes which he has described are always of a physiological nature; he believes that their occurrence, without any morbid changes in the tympanic cavity, would not justify the conclusion that a pathological process preceded their formation. Similar connections between the posterior, anterior, and exterior surface of the vertical ramus of the incus with the structures of the tympanum, are shown to be normal. The first point agrees with the investigations of Lincke; the second point agrees with the statement of v. Troeltsch.

The horizontal ramus of the incus may be joined to the external wall of the tympanum, and with the mastoid cells, by similar membranous connection. The union with the outer wall has already been shown by Zaufal to be a normal one. This was found by Urbantschitsch in eighty per cent. of all the adults examined.

The membrane so frequently found between the tendon of the tensor tympani and the antero-superior wall of the tympanum, as described by Prussak, Gruber, and Zaufal, has been observed in adults by Urbantschitsch, sometimes as a perfect membrane, and sometimes perforated in the middle or represented only by a few adhesive bands.

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[1] Beiträge zur Entwickelungsgeschichte der Paukenhöhle. Report of Royal Academy of Sciences, Vienna, Jan. 1873.

Hyrtl's discovery that osteophytes are regularly found in the tympanum of many of the mammals, is carried still further by Urbantschitsch, who shows that there is in the tympanum of man, a series of membranous bands containing structures similar to osteophytes which are of a physiological nature. They were found in one-third of all the adult tympana examined. According to Hyrtl, these osteophytes are formed in the tympana of animals during the early years of life; Urbantschitsch has found them in the tympanum of the new-born child sixteen times in fifty examinations. These are usually found on the eminentia pyramidalis. They may also be found on the hinder and outer wall of the tympanum, and on the border of the round window.

They are usually in connection with a membranous or cord-like structure. Meckel has described a bony ridge between the eminentia pryamidalis and the oval window. In one case, among fifty examined, Urbantschitsch found a bony growth between the eminentia pryamidalis and the inner wall of the tympanum.

The posterior wall of the tympanum often contains a bony formation resembling a lamella. "This forms, either alone or in combination with membranes, a partition which divides the posterior portion of the tympanic cavity into a superior, larger space, and an inferior, smaller one."

Function of the Round Window and its Membrane.—In 1871 I made some investigations into the condition of the membrana secundaria, or the membrane of the round window, during the movements of the ossicles of hearing; and the excursions performed by it were measured under the microscope. During these investigations I also noticed the effect of varying labyrinthine pressure upon the small bones of hearing and the membrane of the round window.

All the observations were made upon temporal bones from human subjects, as soon as possible after death. Of the ten specimens thus used, eight were from males and two from females; the ages varying from six years to forty-five years. During the intervals between the experiments, the temporal bones were kept in a ten per cent. solution of alcohol. To prepare the bones for examination under the microscope, the Eustachian tube was removed up to its bony portion, but the membrana tympani, with the annulus tympanicus, the chain of ossicles, and the labyrinth, were left entirely intact.

In order to obtain the best view of the fenestra rotunda, the floor of the tympanum was removed as high as the round window, till it and the promontorium cochleæ were fully exposed. The chief difficulty experienced in thus exposing the round window is the liability to encroach upon the posterior semicircular canal.

To avoid this, a view of the window was first gained, by cautiously chiselling away the posterior portion of the floor of the tympanum. Then the entire preparation was turned forward about an axis running through the porus acusticus internus and the external auditory meatus, and the bone was chiselled away in all directions, excepting outward and upward, till a perfect view of the round window was obtained. The preparation was then fastened firmly in a vise, and laid so as to be conveniently approached by a microscope, and to receive, by means of a condenser, light from a kerosene lamp. The preparation now lay with the chain of ossicles exposed from underneath, and the membrana tympani secundaria visible at an angle of about 45°. These were sprinkled lightly with powdered starch,[1] so as to insure bright vibrating points.

Sources of Sound.—As sources of sound, four organ-pipes were used, of respectively 50, 140, 630, 1160 vibrations per second. The first was a reed-pipe, the three remaining ones were stopped pipes. These were connected with the ear, in each case, by means of a gutta-percha tube one metre long, and one-half centimetre wide, fastened to the side of the reed-pipe; but in the case of the other three, at the closed end.

The free end of the connecting gutta-percha tube was supplied with a tapering glass tube, pointed with sealing-wax, moulded to the external auditory meatus, thus procuring an air-tight communication between the organ-pipe and the membrana tympani. All unwished-for vibrations were avoided by placing the pipes upon separate tables, and in some instances they were held in the hand during the sounding of a note. This necessitated all vibrations which reached the ear to pass through the connecting gutta-percha tube.

The position of the glass tube in the external auditory meatus has great influence on the experiments. When the tube is directed downward and forward, the experiments are almost invariably successful, but in any other position they may be partially or entirely unsatisfactory. For, in the former position, the sound-waves strike more directly against the membrana tympani and the hammer, whereas in any other position they are forced against the sides of the auditory canal, and are deflected and destroyed before they reach their destination. This seems to indicate that sound, entering the external auditory meatus, produces no easily distinguishable effect upon the ossicles of hearing and the labyrinth, by simple conduction through the bony walls of the auditory canal. It must, indeed, be forced against the membrana tympani, and through it act upon the ossicula auditus. These, in turn, act like a lever, communicating their movements to the fluid of the labyrinth and the membrane of the round window.

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[1] Lissajou's method.

On producing a note upon a given organ-pipe connected with the ear, as already described, the chain of bones was seen to vibrate in excursions, bearing a fixed relation to each other.[1] At the same time, their motion was communicated through the labyrinth to the membrane of the round window, upon which the excursions of the shining particles maintained an almost constant relation of equality with those of the stapes.

The excursions, both upon the chain of ossicles and upon the membrane of the round window, varied in their length with the pitch of the note produced by the organ-pipe; the longer excursion corresponding to the deeper note.

By the use of a siren, which was fitted to a pipe opened at its side to accommodate the gutta-percha connecting tube, excursions synchronous with the revolutions of the disk were produced upon the chain of ossicles and the membrane of the round window. These could be counted during the early revolutions of the disk; but as they increased and the note ascended, the vibrating points became lines diminishing in length with the increasing rapidity of the revolution.

During these observations one preparation was found which did not respond to the notes of the organ-pipes as the previous ones had done. The ossicula auditus manifested some very slight vibratory motions, but the membrane of the round window showed none.

In order to explain this apparently abnormal result, and to find out whether an increased or diminished labyrinthine pressure could have produced it, the following experiments were instituted:

Upon a perfect petrous bone, which failed to respond to the sounds produced by the already mentioned pipes, the superior semicircular canal was opened at its summit, and to this opening one end of a small glass tube, one centimetre long by five millimetres wide, was hermetically sealed. The bone thus modified was placed in water and brought under the air-pump, in order to remove any air which might have entered the labyrinth. After these arrangements the glass tube, sealed to the superior semicircular canal, was connected by a gutta-percha tube, of similar diameter, to a reservoir of water, consisting of a funnel placed in a retort-holder, and which could be elevated or depressed at will. The pressure exercised by the water upon the labyrinth could be easily seen with the unaided eye, as the varying height of the funnel caused the column of water to press with a greater or less force upon the membrane of the round window.

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[1] The movements of these bones, in connection with sound-waves, have also been observed, and their excursions measured by Politzer and Buck. In 1870, A. H. Buck observed and measured vibrations on the membrana tympani secundaria, in one preparation. (Archives of Otology, vol. i.)

With these modifications, the preparation, which formerly failed to respond to the notes of the organ-pipes, was placed in connection with the sources of sound, and the chain of bones, as well as the membrane of the round window, was observed during the passage of a note to the ear.

The desired excursions now became apparent upon the hitherto abnormal specimen, and resembled those upon other preparations, so long as the pressure was maintained at a certain grade; but when increased or diminished beyond a given point, the excursions ceased upon the ossicles and the membrane of the round window. *This cessation was observed to take place sooner during the occurrence of high than of low and powerful notes.*

The human ear, in the living state, sometimes fails to perceive high notes, while lower ones are distinctly heard.

Perhaps such phenomena may be explained by an application of the results obtained in these investigations, in which artificial labyrinthine pressure interfered with the action of the chain of ossicles and the membrane of the round window, sooner in connection with high notes than with lower ones.

In cases of hemorrhagic or serous effusions into the internal ear, it may be supposed that the accumulation of pathological fluids in the labyrinth interferes with the action of the chain of bones and the membrane of the round window, just as the artificial pressure did in my experiments.

In addition to these destructive changes, which follow pathological processes in the ear, the perilymph of the labyrinth may be subject to great fluctuations in its amount, since the arachnoid sac and the labyrinth are so intimately connected, as experiments of Weber-Liel[1] and Hasse[2] show. According to the latter, "all vertebrates possess a duct which originates in the vestibule; and in all animals, with the exception of the Plagiostomes, in which it passes directly to the surface of the skull, this duct enters the cavity of the cranium, and there terminates either in a closed sac at the confines of an epicerebral lymph-cavity, or opens into the same. This is the ductus endolymphaticus or the aquæductus vestibuli with the saccus endolymphaticus, the former of which, in most vertebrates, arises from the sacculus, that is, from the inferior portion of the vestibule. Every increased or diminished pressure of the fluid of the liquor cerebrospinalis in the subarachnoid cavity will make itself felt *per continuitatem* through the saccus and the ductus endolymphaticus, in the interior of the auditory apparatus, in the endolymphatic cavity and upon the terminal apparatus of the auditory nerve found therein." We may explain thus most easily the impairment of hearing for high tones in cases of increased pressure.

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[1] M. f. O., August, 1870.

[2] Anatomische Studien, No. xix. p. 768.

In concluding this account of my experiments, I would call attention to a fact of interest respecting the direction of a line described by a vibrating starch-point upon the membrane of the round window. It was observed that such a line invariably remained parallel to the plane of the membrana tympani.

An explanation may be found in a probable unequal tension of the membrana tympani secundaria, dependent upon the manner of its insertion into its frame.

The following deductions may be drawn from the foregoing experiments:

1. The excursions of the chain of ossicles of hearing bear a fixed relation to each other.
2. The excursions of the ossicles of hearing are communicated through the labyrinthine fluid to the membrane of the round window.
3. The excursion of the membrane of the round window generally equals that of the stapes; but it may equal that of the membrana tympani, at the point of the manubrium mallei.
4. The pressure within the labyrinth, increased beyond certain limits, causes cessation of the action of the membrane of the round window and the chain of ossicles of hearing. This occurs sooner in connection with high notes than with the lower notes of the scale.
5. If the labyrinthine pressure is greatly diminished or totally removed, the chain of ossicles may continue to vibrate, but they exert no influence upon the membrane of the round window.
6. The vibrations of the membrane of the round window vary from $\frac{1}{1000}$ mm. to $\frac{32}{1000}$ mm.[1]

A difference of opinion has existed respecting the part the membrane of the round window plays in the conduction of sound. Without doubt the excursions of the ossicles of hearing are conveyed through the water of the labyrinth to the membrane of the round window, as shown by the experiments of A. H. Buck and of the author, and later by the corroborative experiments of Weber-Liel.

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[1] All the measurements I obtained may be found recorded in the Archives of Oph. and Otol., 1872.

Some authorities have thought that perhaps the membrana tympani secundaria participates *directly* in the sound-waves transmitted to it by the membrana tympani through the air of the tympanum. Johannes Müller inclined to this opinion, but the experiments of Schmiedekam and Hensen seemed to show that he was incorrect in his views. Recently Weber-Liel[1] has performed a series of experiments which are not only very interesting, but tend to decide this question affirmatively.

These experiments were performed on nine fresh preparations of the ear; seven were from man, one from a calf, and one from a horse. The ears were prepared for examination in a way similar to that described on page 93.

The sources of sound were the human voice and three organ-pipes; the fundamental notes of the latter were such as gave 180, 210, and 540 vibrations per second. The sounds from these pipes and the voice were conveyed to the prepared ears, in a manner similar to that described on p. 93. The preparations were sprinkled with starch, illuminated, and held firmly, in the manner described, and the first results of Weber-Liel's observation were in entire harmony with those obtained by the author.

Weber-Liel carried his experiments further, and obtained the following results:

1. If the incudo-stapedial joint is divided, and the incus pushed somewhat aside, and then the tympanic cavity hermetically closed by a firmly inserted pane of glass (a microscopic cover) on the artificially opened side, while the Eustachian tube is kept slightly open, microscopic examination of the membrane of the round window through the glass cover revealed *almost invariably*, that also under these circumstances during the sounding of the pipes and during the singing of deeper notes, the particles of starch or the reflecting points on the membrane performed excursions, which were but slightly less (1½ : 2) than those occurring before the division of the incudo-stapedial joint; these excursions, however, were observable only on certain parts of the membrana tympani secundaria. They did not occur when the cavity of the tympanum was reopened. On the head and rami of the stapes faint simultaneous vibrations were observed in two cases.

2. Upon slightly rarefying or condensing per tubam the air in the tympanic cavity of the preparations arranged as above, no change was produced in the width and direction of the excursions; when the air became more condensed, the high notes first ceased to produce vibrations; with increasing condensation, the deeper notes ceased to have effect.

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[1] Centralblatt f. Med. Wiss., Jan. 8, 1876.

3. In order to exclude the possibility of the communication of sound waves from the oval window (foot-plate of stirrup) through the labyrinth to the membrana tympani secundaria, the labyrinth was opened and the vestibule exposed from behind. After the fluid of the labyrinth had escaped, sound-waves conducted by the membrana tympani to the labyrinth, produced no visible effect on the membrane of the round window. This negative result is attributable to the loss of pressure consequent upon the escape of the labyrinth-fluid; for, when the cochlea was sawed transversely through, and a narrow glass tube placed in the transverely sawed scala tympani, and the latter, with the glass tube, filled with various heights of water, by means of which once more a certain amount of pressure was brought upon the labyrinth side of the membrane, then, when the tympanic cavity was again closed, immediately the excursions became once more visible upon sounding the organ-pipes or singing.

4. With some of the preparations, a glass tube was cemented to the temporal bone, and through this tube, by means of a rubber pipe, the labyrinth being undisturbed, sound-vibrations were conveyed to the bones of the head. No excursions were perceptible, neither with the tympanum opened nor closed.

These experiments seem to prove that the membrane of the round window may, to a slight extent, be set in vibration by sound-waves from the membrana tympani conveyed through the air of the tympanic cavity.

The Power of Muscular Accommodation.—According to Prof. Lucæ's experiments,[1] the ear has, in the tensor tympani and stapedius muscles, an apparatus for accommodating itself to various sounds. The first muscle aids in the accommodation for low musical tones, the latter accomplishes the same for high, unmusical sounds.

Abnormal contraction of the tensor tympani, with insufficient antagonism of the stapedius, produces a modification of perception, termed by Dr. Lucæ "low hearing;" an analogous condition of the stapedius muscle in its relation to the tensor tympani produces "high hearing."

Action of the Tensor Tympani and Stapedius Muscles.—Confirmatory observations of Drs. Mach and Kessel[2] show that the traction on the stapedius muscle drives the head of the malleus inward, and the lower part of the membrana tympani outward. The substance of these observations is in harmony with the celebrated theories of Weber.

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[1] Die Accommodation und Accommodationsstörungen des Ohres. Dr. A. Lucæ, Berliner Klin. Wochenschrift, 1874, No. 14. Abstract by Dr. Jacoby, Archiv f. O., Band ix. pp. 184–185.

[2] Beiträge zur Topographie und Mechanik des Mittelohrs. Wiener Sitzungsb., 23 April, 1874.

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CHAPTER II.

EUSTACHIAN TUBE AND MASTOID PORTION.

ANATOMY.

THE Eustachian tube, though discovered by Vesalius, gets its name from Bartolommeus Eustachius,[2] who gave a more complete description of it than any of his contemporaries or predecessors. Though it is generally conceded that Vesalius was the discoverer of the tube, some authorities think that even Alcmeon[3] and Aristotle[4] knew of its existence.

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[1] Pflüger's Archiv für Physiologie, I. Jahrgang. ; Bonn, 1869.

[2] 1500–1574.

[3] 570 B. C.

[4] 384–322 B. C.

The Eustachian tube is the only means of aerial communication between the pharynx and middle ear. It opens into the pharynx a little above the floor of the nose, and passes backward, upward, and outward to the cavity of the tympanum, forming an angle of 40° with the horizon, and 135° with the axis of the external auditory canal. The pharyngeal mouth of the tube is wide, but the tube narrows rapidly to the *isthmus*, from which point it widens again to the tympanic cavity. It therefore resembles, somewhat, two short and wide-based cones, placed point to point, their junction marking the position of the isthmus. The pharyngeal mouth of the tube is oval in shape, being 9 mm. high and 5 mm. wide. At the isthmus, the junction of the osseous with the cartilaginous part of the tube, the diameter is 1.5 to 2 mm., and the greatest diameters of the osseous canal vary from 4 to 4.5 mm. The entire length of the Eustachian tube is 35 mm., 1⅜ inch; the bony portion being 11 mm., and the cartilaginous part 24 mm. long.

Bony Portion of the Eustachian Tube.—As already indicated, the Eustachian tube is composed of a bony and a cartilaginous portion. The former lies entirely within the petrous bone;[1] the latter portion is joined to the former and is about two-thirds of the entire tube. The calibre of the bony portion is triangular, the angles, however, are rounded by the mucous lining of the tube. Its average diameter is about 2 mm. The outer wall of the three composing this triangular bony tube, belongs to the pars tympanica, the tympanic bone, the inner wall separates the tube from the carotid canal, and the upper wall is formed internally by the septum tubæ, and the floor of the canal for the tensor tympani, and outwardly it unites with the outer wall of the bony tube in the petro-tympanic or Glaserian fissure. The posterior wall of the bony portion of the canal is somewhat longer than the anterior wall. Usually the bony Eustachian tube is twice as wide as the semi-canal of the tensor tympani, but in some instances these relations are reversed, as shown by Rüdinger.

Cartilaginous Portion of the Eustachian Tube.—In order to understand the true form of this part of the Eustachian tube, one must imagine a shell of cartilage, not quite an inch long, bent so that a section of it at right angles to its long diameter resembles a hook or shepherd's crook. The longer portion of this section of cartilage will represent a section of the inner wall, the shorter portion represents that of the anterior or outer wall, and the curve shows the position of the roof of the Eustachian tube. (Fig. 32.) It will be seen, therefore, that this part of the tube is not a complete and round cartilaginous canal, but rather a flattened tube, the posterior wall and roof of which are made entirely of cartilage, while the anterior wall is of cartilage only in its upper part, its lower portion being *muscular*[1] and completing the tube. The upper part of the inner cartilaginous wall, as well as the roof of the tube, is fastened to the base of the skull by means of the basilar fibro-cartilage. The lower end of the inner wall is movable. That part of the cartilage of the Eustachian tube which curves forward to form the upper part of the outer or anterior wall of the tube, is widest and most movable in its middle portion; it is narrower and more firmly fixed at its two extremities, viz., above, where it is joined to the jagged bony edge of the osseous canal, and below, to the pterygoid process.

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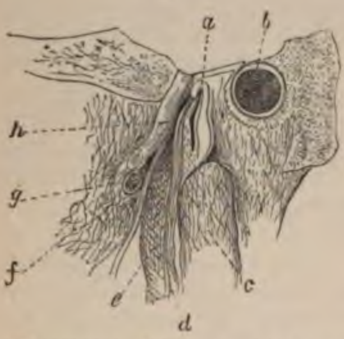
[1] In some cases the large wing of the sphenoid bone unites in the formation of the osseous part of the Eustachian tube, or at least it forms with the pars petrosa, the sulcus petrosphenoidalis for the reception of the cartilage of the tube. (Rüdinger, Die Ohrtrompete, p. 2.)

Fig. 32.



Transverse Section of the Cartilaginous Part of the Eustachian Tube near the Foramen Ovale. (Henle.)—*b*. Section of the internal carotid. *a*. Cartilage of the tube. *h*. Third branch of the trigeminus. *g*. Middle meningeal artery. *f*, *e*. Transverse section of the external and internal pterygoid muscles. *d*. M. sphenostaphylinus (tensor palati). c. Transverse section of the M. petrostaphylinus (levator palati).

The calibre of the tube, in the main, is not round, but cleft-like, and slightly sigmoid in shape; however, that portion of the calibre lying in the curve formed by the cartilage as it turns forward, *i. e.*, that part lying entirely within cartilaginous boundaries, is round and more open than the rest of the lumen of the tube, owing, probably, to the stiffness of the cartilage. This fact would always insure at least a portion of the tube's being more likely to be free from obstructions or from having its two sides stick together. To this more patulous part, Rüdinger has given the name of safety-tube (Sicherheitsröhre), and to the cleft-like calibre of the tube below this rounder lumen, he has given the name of "accessory cleft" (Hilfsspalte), "since, according to Du Bois Raymond, these terms express most clearly their physiological importance."[2]

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[1] Formerly, this part of the canal was called membranous, but since muscular tissue is so intimately concerned in its formation, Rüdinger proposes to call it muscular, as being more truly descriptive.

[2] Rüdinger, Ohrtrompete, p. 7.

The posterior cartilaginous wall of the Eustachian tube projects well into the pharynx, forming there a prominent ridge, the anterior boundary of the fossa of Rosenmüller. Into the latter, the Eustachian catheter is often placed in mistake for the pharyngeal mouth of the Eustachian tube. When the latter is to be catheterized, this prominent ridge, marking the termination of the cartilage of the Eustachian tube, should be sought for and thoroughly located with the beak of the catheter. In order to do this it is well to allow the catheter to pass first into the fossa of Rosenmüller, then to glide gently forward over the aforesaid cartilaginous lip, by which act the beak can hardly escape going into the pharyngeal mouth of the tube.

As already stated, the cartilaginous shell of the Eustachian tube is adherent at its curve or roof to the base of the skull, by means of the basilar fibro-cartilage; the edges of the shell, *i. e.*, the edges of the anterior and posterior lips of the cartilage of the tube, are free, and from them important muscular structures arise. The inner dilator of the tube, or the *salpingo-pharyngeus* muscle, is one of these, and arises from the edge of the posterior cartilaginous wall of the Eustachian tube, and passes towards the superior constrictor of the pharynx. There is also an intimate topographical[1] relation between this inner wall and the inner surface of the levator palati (petrostaphylinus, Henle), which muscle, in conjunction with the salpingo-pharyngeus, the inner dilator of the tube, brings about movements of the cartilage. "If the levator palati be pulled upon in a fresh preparation, the under end of the inner plate of cartilage will be pushed inward and upward, by which means the pharyngeal mouth of the Eustachian tube will be considerably widened."[2] Since, then, the conjoined action of these two muscles, the levator palati and the salpingo-pharyngeus, together with the dilatator tubæ or tensor palati, yet to be described, brings about these changes in the pharyngeal mouth of the Eustachian tube, it can easily be seen how the act of swallowing, which brings them into action, opens the tube and ventilates the middle ear.

Tensor Palati Muscle.—The most important of all the muscles of the Eustachian tube is the tensor palati.[3] This muscle arises by a flat tendon from the posterior edge of the hard palate, in intimate connection with the tendon of its fellow of the opposite side, and, gradually narrowing into the tendon which passes around the pterygoid hook, spreads out again from this point into a fan-shaped muscular layer, the free, broad edge of which is inserted into almost the entire length of the anterior lip of the cartilage of the Eustachian tube.

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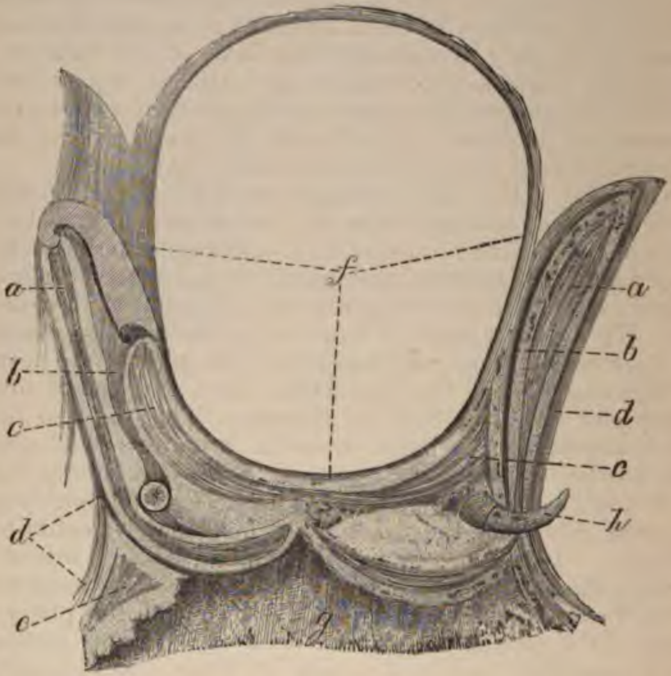
[1] This muscle sends a few fibres to the posterior cartilaginous wall of the Eustachian tube near the junction of the cartilage with the bony portion of the tube.

[2] Rüdinger, Die Ohrtrompete, p. 4.

[3] This muscle has received various names: Tensor veli; Tensor veli palatini; Dilatator tubæ (Rüdinger); Spheno-salpingo-staphylinus, etc.

Fig. 33.



DIAGRAMMATIC SECTION THROUGH THE EUSTACHIAN TUBE, THE MUSCLES AND FASCIÆ. (On the left side, the section is supposed to be a vertical one passing through the tube; on the right side, it is supposed to pass under the floor of the tube.) (Weber-Liel.)—*a*. Tensor veli muscle. *b*. Fascia salpingo-pterygo-staphylina. *c*. Levator palati muscle. *d*. Fascia pharyngea externa, passing into the tubal fascia above. *e*. Buccinator muscle. *g*. Hard palate. *h*. Pterygoid hook. *f*. Fascia pharyngea interna.

Respecting the much-disputed origin of the tensor palati, it may be said that, according to the investigations of Dr. Urbantschitsch,[1] there are individual variations in the origin of this muscle from the membranous part of the Eustachian canal. In some cases such an origin is wanting.

Hence has arisen the great difference of opinion between many noted investigators of the anatomy and physiology of this tube. A very important variation also occurs in the connection between the tensor tympani and the tensor palati, for sometimes such a connection is not to be found, while in other cases it undoubtedly exists. In one instance it was found that the spindle-shaped tendon of the tensor tympani passed entirely into the middle belly of the tensor palati muscle. These facts are in harmony with the well-known investigations of Weber-Liel.

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[1] Zur Anatomie der Tuba Eustachii des Menschen. Victor Urbantschitsch. Med. Jahrbuch, 1 Heft, 1875.

By the contractions of this muscle the anterior wall of the cartilage of the tube is pulled outward and downward, and thereby the calibre of the canal is widened.

According to the investigations of Rüdinger,[1] it is shown that there is a direct connection between the tensor palati (Dilatator tubæ) and the tensor tympani muscle. Not only do the tendinous fibres, but also the muscular fibres, of the one pass over into those of the other, at the upper part of the Eustachian tube. This connection is of the greatest importance when considering the cause and treatment of certain forms of hardness of hearing due to a kind of paresis in the tensor veli.

The Inner Pterygoid Muscle.—This muscle is considered by Weber-Liel as specially belonging to the muscles of the Eustachian tube.[2] According to his observations some of the upper, shorter, and hinder fibres of this muscle are inserted into the fascia of the floor of the tube throughout its length, and are then lost in the fibrous covering of the petrous bone. Its function is that of a tensor of the fascia of the Eustachian tube.

The Ligamenta Salpingo-pharyngea.—Dr. Zuckerkandl[3] has described a constant and peculiar anatomical connection between the Eustachian tube and the constrictors of the pharynx, under the name of the ligamenta salpingo-pharyngea. His statement is that upon laying bare the posterior wall of the pharynx and dissecting off the mucous membrane, along the periphery of the pharyngeal opening of the Eustachian tube and adjacent parts, there will be found three, four, or five, perhaps more, tendinous, rarely elastic cords, attached to the pharyngeal end of the hooked cartilage of the tube, and to the outer wall of the same, which in their fullest development are likened to the tendinous cords of the valves of the heart. This anatomical arrangement, it is said, produces a free opening of the Eustachian tube at each contraction of the superior and middle constrictor of the pharynx.

The same observer has described a salpingo-pharyngeal recess below the faucial mouth of the Eustachian tube.[4]

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[1] Op. cit., p. 6.

[2] Progressive Schwerhörigkeit, Berlin, 1870, pp. 68–71.

[3] Zur Anatomie und Physiologie der Tuba Eustachiana. M. f. O., 1873, No. 12.

[4] Monatsschr. f. Ohrenh., No. 2, 1875.

The Plica Salpingo-palatina and the Plica Salpingo-pharyngea.—The two folds of mucous membrane known as the plica salpingo-palatina and the plica salpingo-pharyngea, are greatly concerned in the form and expansion of the mouth of the Eustachian tube, both in its condition of rest, and also in the active and passive movements of the soft palate. The intimate connection between the movements of the soft palate and the Eustachian tube is dependent not only on their common muscles, but upon the two folds just named. The former fold constitutes the anterior edge of the tubal mouth, and is intimately connected with the tensor palati muscle. The latter fold, the salpingo-pharyngea, is of more importance, according to Zaufal, and is formed as follows: The under part of the lip of the Eustachian mouth in the pharynx gradually narrows into a mere fold of mucous membrane, very rich in glands. To this fold, a few

Fig. 34.

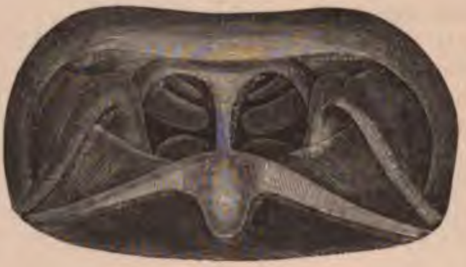
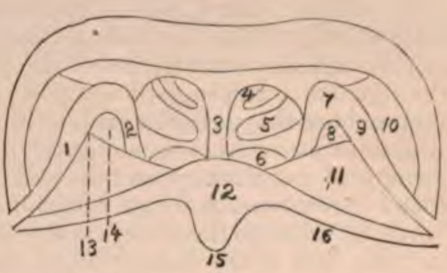


Fig. 35.



The Nasopharynx viewed from Behind. (Zaufal.) 1. Plica salpingo-pharyngea. 2. Plica salpingo-palatina. 3. Septum narium. 4. Superior turbinated bone. 5. Middle turbinated bone. 6. Inferior turbinated bone. 7. Curve of the tubal cartilage. 8. Mouth of Eustachian tube. 9. Tubal ridge. 10. Fossa of Rosenmüller. 11. Levator palati. 12. Azygos uvulæ. 13. Posterior tubal sulcus. 14. Anterior tubal sulcus. 15. Uvula. 16. Arcus palato-pharyngeus.

centimetres in length, the name of plica salpingo-pharyngea has been given.[1] It runs in the same direction as the plica salpingo-palatina, from the posterior and under end of the tubal ridge downward on the side of the pharynx, dividing the latter from the upper lamina of the velum, to unite with the posterior edge of the levator palati muscle.

Mucous Membrane of the Eustachian Tube.—The mucous membrane of the Eustachian tube is a continuation of that of the pharynx. It is supplied with ciliated epithelium, the cilia of which move in a direction from the tympanic cavity towards the pharynx, thereby favoring the passage of fluids from the cavity of the drum and tube into the throat.

The Eustachian tube is very rich in glands at certain places; although the upper concave portion of the cartilaginous roof of the canal is entirely free from glands, the sides of the tube, in the pharyngeal portion, are richly supplied with "acinous mucous glands," emptying into the folds of mucous membrane, as shown by Rüdinger. These mucous glands do not differ from those of the œsophagus and pharynx. In the upper portions of the tube, towards the tympanic cavity, all glands become sparse.

In addition to the glands just named, Gerlach[2] has shown that the mucous lining of the cartilaginous portion of the tube is richly supplied with follicular glands, which are most numerous at its middle part. Placed still deeper in the submucous connective tissue, are numerous acinous glands. The follicles of the tubal mucous membrane are about half as large as those of the pharynx, but take in the entire depth of the mucous membrane.

Tonsilla Pharyngea.—According to the investigations of Santorini[3] and Luschka,[4] it is shown that the lining structures of the roof, and to a great extent the hinder wall of the nasal part of the pharynx, are composed of a tissue so strikingly like the substance of the tonsils that it has been named the "pharyngeal tonsil."

Luschka states that this spongy tonsillar substance, of a maximum thickness of 7 mm., which he has never failed to find, extends from the posterior boundary of the roof of the nasal cavity to the edge of the foramen magnum of the occipital bone, where it assumes a more or less uneven surface, or, breaking up into separate sebaceous glands, is gradually lost in the posterior wall of the pharynx. The same kind of structure forms the chief constituent of the recessus pharyngeus, and extends in a thinner layer over the ridge of the pharyngeal mouth of the Eustachian tube.

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[1] E. Zaufal, Archiv f. Ohrenheilkunde, vol. xv., 1879, p. 97.

[2] Zur Morphologie der Tuba Eustachii. Sitzungsberichte d. Erlanger Physicalisch-Med. Soc. Abstract by von Troeltsch, A. f. O., vol. x. p. 53, 1875.

[3] Parma, 1775.

[4] Der Schlundkopf des Menschen. Tübingen, 1868, pp. 20–27.

Differences in Size and Shape of Mouth of Eustachian Tube.—Urbantschitsch[1] has described great variations in the shape and size of the pharyngeal mouth of the Eustachian tube. These variations occur not only in those of the same age, but also in the same individual. The variation in form of the cartilaginous part of the tube is observed to occur in both the posterior and anterior wall. The former may terminate in a sharp point, or it may be very blunt and rounded at the lower and posterior end; it may also be corrugated on the surface towards the lumen of the pharynx, or curled decidedly upward and forward towards the so-called floor of the tube. Another curious deviation found in the posterior wall of the tube is a bifurcation, the hinder limb pointing backwards, the anterior curling forwards. The various deviations in shape, position, and direction of the walls of the tube, described by Dr. Urbantschitsch, apply only to the mouth, and not to the cartilage in its upper and inner parts. They may, in many cases, cause a widening or a narrowing of the mouth without producing changes further up the calibre of the tube.

According to the same authority, the direction of the pharyngeal mouth of the tube is generally oblique from above and in front, backward, and downward; in exceptional cases, the axis of the mouth of the tube may run vertically or even horizontally.

Bloodvessels and Nerves of the Eustachian Tube.—The arteries supplying the Eustachian tube are the *pharyngeal* from the external carotid, the *middle meningeal branch* of the internal maxillary, and various small branches of the *internal carotid.*

The nerves are distributed as follows: The tensor palati, or the dilatator tubæ muscle, is supplied by a branch from the otic ganglion, and also by a motor branch from the internal pterygoid nerve, a muscular branch of the smaller division of the inferior maxillary nerve. The levator palati muscle is supplied by the facial nerve through its connection with the Vidian and petrosal nerves, as well as by a branch from the vagus. The inner dilator of the tube, the salpingo-pharyngeus, is supplied by the glosso-pharyngeal nerve. The inner pterygoid muscle is supplied by the inferior maxillary nerve. The mucous membrane of the tube is supplied by branches of the glosso-pharyngeal nerve, which also supplies the mucous membrane of the tympanic cavity.

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[1] Anatomische Bemerkungen über die Gestalt und Lage des Ostium pharyngeum tubæ beim Menschen. A. f. O., vol. x. pp. 1–7, 1875.

The Mastoid Portion of the Temporal Bone and its Cells.—The mastoid portion is that highly important part of the middle ear situate behind and partly below the cavity of the tympanum. It corresponds to the protuberance behind the auricle. This hollow portion is developed partly from the squamous portion, but chiefly from the petrous part of the temporal bone. As is well known, the temporal bone is formed from three distinct pieces, the squama, the annulus tympanicus, and the petrous pyramid. The squama is divided into two parts, viz., the vertical and the horizontal portions. The horizontal portion is subdivided into an inner and an outer lamella, the latter of which forms part of the air-cavities of the mastoid portion. This portion of the temporal bone has a distinct existence by the fifth fœtal month. The mastoid portion is really a continuation of the petrous part of the temporal bone, backward and downward. In the new-born child it extends half an inch beyond the hindmost boundary of the squama, and forms a three-sided pyramid, the point of which is behind, the base of which is in front towards the tympanum, and the sharp free edge of which is directed downward. The outer surface of this pyramid corresponds of course to the outer wall of the mastoid portion, the inner surface divides the mastoid cavity from that of the cranium, and the upper surface is in the same plane with, and is a continuation backward of, the upper surface of the petrous portion of the bone. All of these features are most clearly seen in the new-born child.

The *upper surface* of the mastoid portion unites with the postero-external edge of the roof of the tympanum. This is marked by a furrow until immediately after birth, when it usually becomes invisible.

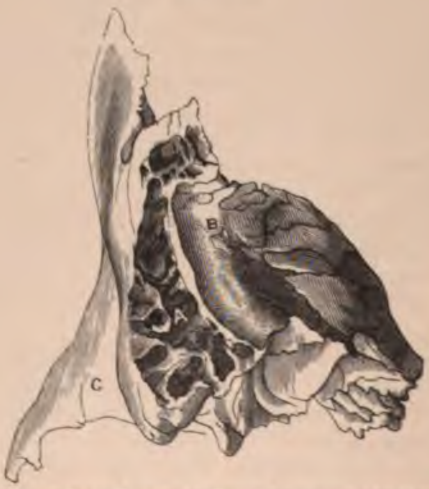
In a child a few months old, the *outer surface* shows a deficiency at its upper and anterior edge, in the shape of a fissure named the mastoid-squamous. Sometimes, at this early age, the fissure is not at all marked, its place being represented by a series of irregular openings varying from two to three mm. in diameter, as though union between the squama and the outer mastoid wall was already far advanced.

The *inner surface* is quite concave, and over it runs a furrow, which at last is fully developed into the sigmoid sinus.

The *mastoid foramina* are found near that point where the upper and under edges of the mastoid portion meet. In some cases the foramina are not complete until the occipital bone joins the mastoid edges. These openings are for the passage of arteries to the dura mater, and for small veins which connect the transverse or lateral sinus with the veins of the scalp.

Mastoid Cells.—Within the mastoid portion are found the mastoid cells. These are a series of bony air-chambers of variable size, communicating with one another by means of foramina in their thin walls. They communicate with the tympanic cavity by means of the mastoid antrum, and are lined by a continuation of the same mucous membrane lining the Eustachian tube and tympanic cavity. The quantity and development of these cells vary, not only in different individuals, but in the same individual, on the two sides. It is of the highest importance to understand their general distribution in the adult bone, in order to diagnosticate and treat inflammatory processes arising there, or which have spread to that part from the tympanic cavity.

Fig. 36.



MASTOID PORTION OF THE LEFT TEMPORAL BONE LAID OPEN AND VIEWED FROM BEHIND.—A. Mastoid cells extending from the mastoid process below, upward and inward, over the lateral sinus B. C. The zygoma.

In the mastoid portion of the child it is found that the septum dividing the mastoid cavity from the sigmoid sinus is very *thick*, and hence inflammation is not likely to pass from the former to the latter, as it is in adults, in whom this septum is always thin. Hence, in very young children, meningitis very rarely, if ever, occurs from inflammation of the mastoid cavity, from which inflammation tends to pass outward rather than inward, not only because the dividing septum between it and the sigmoid sinus is thick, but because, as already stated, the outer wall of the mastoid portion is imperfect in early childhood. This is the reverse of what we find in the adult, so that in the latter, everything favors a passage of disease of the mastoid cells inward towards the brain, while in the child the conditions are in favor of a passage outward of disease in this region.

A depression sometimes occurs in the sigmoid groove of adults near the foramen jugulare. This is supposed to be due to the interference in the circulation of blood, by a ridge of bone, which is found immediately behind the edge of the jugular foramen in such cases. In some instances, instead of depressions at this point in the sigmoid sinus, erosion of the bone is found, and a true perforation exists.[1]

The lower pointed part of the mastoid portion is known as the *mastoid process;* to it the sterno-cleido-mastoid muscle is attached. The development of the mastoid process is greater in the strong and muscular, while it is less developed in the weak and in children. The mastoid portion is also subject to differences in development in different races, being small and solid in negroes, while in Mongolians it is found much more highly developed than in Caucasians, as shown by Welker.

By the eighth month of fœtal life the mastoid cells are very distinctly seen as depressions in the bone of the mastoid portion. These cells are not developed first at that part of the fœtal temporal bone which, at a later period, corresponds to the mastoid process, but from the upper and hinder parts of the mastoid antrum, *i. e.*, from above downward, as demonstrated by Schwartze and Eysell.[2]

In the first year after birth the mastoid cavity loses its pyramidal shape by assuming a more ovoid form, and the mastoid cells are formed gradually. Those which are included in the upper and outer portion of the mastoid portion where it joins the squama, are the most highly developed at this time, and lined with mucous membrane, while the mastoid process as yet contains no air-cells. From this time on, the external differences of this part of the temporal bone are much less than the differences in development of the air-cells within, for the latter are subject to the greatest variations in number and distribution, as can readily be seen in the skulls of adults.

The mastoid antrum, which is a connecting air-chamber between the tympanic cavity and the air-cells of the mastoid portion, is of a triangular shape. Its position is somewhat above, in front of, and further inward, than the rest of the mastoid cells. Its walls, with the exception of part of its outer wall, are formed by the petrous part of the temporal bone, and communicate by numerous perforations with the mastoid cells, with which it is surrounded on all sides excepting in front and on the inner side. Anteriorly it has a wide opening into the tympanic cavity, and on its inner side it is bounded by that part of the petrous bone covering in the horizontal semicircular canal.

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[1] Hauerwaas, Monatsschrift für Ohrenheilkunde, No. 5, 1880.

[2] Archiv f. Ohrenh., Band i., 1873.

It is stated in a valuable paper by Schwartze and Eysell[1] that the general shape of the mastoid cells is that of a hollow pyramid, and that their axes run like the radii of a hollow sphere, towards their centre, viz., the mastoid antrum.

The air-containing cavities fill the entire mastoid portion of the temporal bone, and in most cases they spread downward and outward to the very point of the mastoid process.

Limits of the Mastoid Cells.—The mastoid cells extend as far backwards as the Emissarium mastoideum, where they are in close contact with the outer side of the groove for the mastoid sinus, and they are found as far forward as the external auditory canal. Mastoid cells are also found continuous with those which reach as far forward and upward as the petro-squamous suture, above the point where the outer table of the mastoid portion is nearest the inner table, that is, the outer wall of the sigmoid groove.

In a temporal bone shown in Fig. 36, in which the section of the mastoid portion has been made in the plane of the posterior surface of the petrous portion, and carried through the mastoid where the inner and outer tables nearly meet, characteristic air-cells are seen lying. In a tent-like space, half an inch high, the apex of which points into the cranial cavity, and the floor of which is in the same plane as the upper surface of the petrous portion, cells of the mastoid are also seen. The outer side of this tent-shaped cavity shows on section that it is continuous with and a part of the outer wall of the mastoid portion, which has grown inward, away from the squama.

The lowest limit of the mastoid cells is the tip of the mastoid process. Those cells which are developed from the petrous part of the bone are the largest; those which arise from the squama and lie over the external auditory canal are the smallest.

PHYSIOLOGY.

Some investigators and writers, among whom are Lucæ and Schwartze, have thought that every act of breathing is conveyed to the drum-cavity by a normal tube, and they have declared that this can be shown not only by the oscillations of the manometric column placed in the external auditory canal, but also by direct observation of the motion of the drum-head at each respiration. Politzer, on the contrary, denies this, believing that the tube is opened only at swallowing, and the facts are in his favor.

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[1] Archiv f. Ohrenheilk., Band i. pp. 168–159, 1873.

Mach and Kessel think the movements of the drum-head observed by Lucæ and Schwartze are due to a to-and-fro motion of the column of mucus, in the capillary safety-tube, produced by rarefaction and condensation of the air at the faucial mouth of the Eustachian tube.

L. Blau,[1] of Berlin, reports two cases of movement in the membrana tympani, at each respiration. In both cases the membrana showed pathological alterations; in one it was adherent to the promontory, and in the region of the pyramid of light a small spot was seen to bulge outward at each inspiration, and to sink inward at expiration. In the second case, the patient complained of a clicking in his ear, which could also be heard objectively. In the membrana, in this instance, two cicatrices could be seen, one in front of, the other behind the malleus. The latter, during the respiratory acts of the patient, was seen to move in and out, as the membrana did in the previous case. Swallowing produced neither movement nor the objective sound.

During regular respiration through the nose the relation of the parts about the faucial mouth of the Eustachian tube does not materially change. The pharyngeal opening of the tube either remains at rest or opens and closes slightly with succeeding inspiration and expiration, after a few moments coming again to rest.

On pronouncing the vowels, particularly *a*, *e*, and *i*, the mouth of the Eustachian tube opens downward and forms an oblique triangle on the lateral wall of the pharynx.[2]

According to a subsequent paper by Zaufal,[3] Bidder[4] was the first to examine the normal relations of the parts in the naso-pharyngeal space. His investigations were succeeded by those of Schuh[5] and Voltolini,[6] the latter being the first, however, to view the tubal ridge through the intact nose. Subsequently observations of these parts were made by Michel, in 1873, and by Zaufal, in 1875. The latter examined the movements of the tubal opening by means of long funnels armed with mirrors, introduced into the nares and passed back into the naso-pharynx.[7]

It is now generally conceded, through the labors of Rüdinger and others, that there is a small part of the normal Eustachian tube, the so-called safety-tube, in its upper part, under the cartilaginous hook, always wide enough open to allow a recoil of air to occur from the drum-cavity, if the drum-head is suddenly driven in, as in explosions, and also to permit a slow equalization of pressure in the tympanic cavity, from the pharynx, independently of the act of swallowing. But this safety-canal is not wide enough to allow constant ventilation of the drum-cavity to go on. Therefore, to insure ventilation of the tympanum, the normal tube is opened at every act of swallowing.

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[1] Archiv f. Ohrenheilkunde, Bd. xix. S. 209, 1883.

[2] Die normalen Bewegungen der Rachenmündung der Eustachischen Röhre. Prof. Zaufal, Archiv f. Ohrenh., Band ix., 1875, S. 133, 228.

[3] A. f. Ohrenh., Bd. x. S. 19, 1875.

[4] Dorpat, 1838.

[5] Wiener Med. Wochenschr., No. 3. 1858.

[6] 1861.

[7] Archiv f. Ohrenh., Bd. xii. S. 250, foot-note.

Prof. Moos,[1] after a careful study of the Eustachian tube, conducted chiefly by transverse sections of the frozen preparation, concludes that the tube when in a state of rest is closed at a point just behind the funnel-shaped end of the faucial opening, and that the closure extends over about two-fifths of the length of the canal. On the lower surface or floor of the tube the closure is effected by the longitudinal folds of mucous membrane which, as seen in cross-section, form a considerable prominence, practically a valve, the size of which is subject to individual variations. On the opposite surface of the canal, under the cartilage hook or roof, there is another prominence of mucous membrane, heretofore overlooked. These two prominences or folds of mucous membrane, judging from analogues in animals, seem to facilitate, by their rapid and easy unrolling, the patefaction of the tube.

The islands of cartilage described by Zuckerkandl,[2] and hinted at by Rüdinger,[3] are regarded as fibro-cartilage, having physiologically the function of sesamoid bones, in the mechanism of the tube, by their connection with the submucous tissue, the fascia or ligamenta salpingo-pharyngea and the tendon of the tensor veli. In the horse the inner belly of the abductor tubæ is inserted into such a cartilaginous disk. That the Eustachian tube is practically closed, except at swallowing, is further proven by observations on themselves by Poorten,[4] Rüdinger,[5] and Yule, in all of whom, when the tube was either voluntarily opened as in Yule, or involuntarily opened as in Rüdinger and Poorten, the voice was heard abnormally loudly and painfully. The same is proven by the observations of W. Flemming, of Prague.[6]

Mr. Yule[7] has given an account of the muscular process seen to occur in his own throat during the voluntary act of opening the Eustachian tube, a power which he seems to possess. When he makes the contractions for opening the tube, it is noted: "First, that the velum palati does not change either its position or its shape—in fact, that it remains unmoved; and further, that it does not become tense, but hangs as soft and flaccid to the touch as at ordinary times of rest. Secondly, that the only parts that do move are the two posterior pillars of the pharynx; and their motion is ample and decided, and altogether unmistakable. They both move inwards simultaneously towards the middle line, moving from their old position from one-half to three-fourths of an inch. This action is not spasmodic, but perfectly steady, and can be sustained for some considerable time at will, the pillars maintaining their new position all the while." Mr. Yule is quite satisfied and certain that during this period the Eustachian tube is open, and he concludes that from the flaccid condition of the velum, and also from the fact of its position and form remaining unaltered, the tensor and levator palati can have no participation in the opening of the tube in his case, and that the muscles most evidently concerned are the palato-pharyngei.

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[1] Beiträge zur normalen und pathologischen Anatomie und zur Physiologie der Eustachischen Röhre, Wiesbaden, 1874. Blake's Report, 1875. American Otological Society.

[2] Cenralblattt, 638, 1874.

[3] Op. cit., p. 3.

[4] Monatsschr. f. O., No. 2, 1874.

[5] Ibid., No. 9, 1872.

[6] Ibid., No. 6, 1875.

[7] On Opening and Closing the Eustachian Tube. C. I. P. Yule. Journal of Anat. and Physiol., viii., 1873.

Mr. James Hinton[1] taught that, since the salpingo-pharyngeus is united at its lower attachment with the palato-pharyngeus, and as this muscle during swallowing is drawn inwards, the salpingo-pharyngeus is drawn inwards also, and so draws the projecting cartilaginous lobe of the tube, to which it is attached superiorly, away from the opposite wall. Therefore, the new direction given to the salpingo-pharyngeus by the movement inwards of the pillars of the fauces, is the cause of the opening of the tube. This seems to give but a partial explanation of the mode by which opening of the Eustachian tube is accomplished. In the process, as thus explained, it would seem that the tensor palati and the anterior wall of the tube are supposed to remain fixed, the movement being confined to the muscle attached to and operating upon the posterior wall. In swallowing, however, the velum palati is thrown into motion, and the anterior wall of the Eustachian tube is thereby drawn away from the posterior wall. At the same time, doubtless, the muscles acting upon the posterior wall of the tube are forced into contraction, and help to draw the two walls apart.

Rüdinger[2] agrees with Rebsamen that the opening of the Eustachian tube is brought about by the action of several muscles. The former supposed that the three muscles—the dilator of the tube or tensor veli, the levator veli, and the salpingo-pharyngeus—act simultaneously; by the action of the first, the cartilage hook is fixed and drawn outward; by the action of the other two the posterior wall is drawn inward and upward, the result being a patulence of the Eustachian tube.

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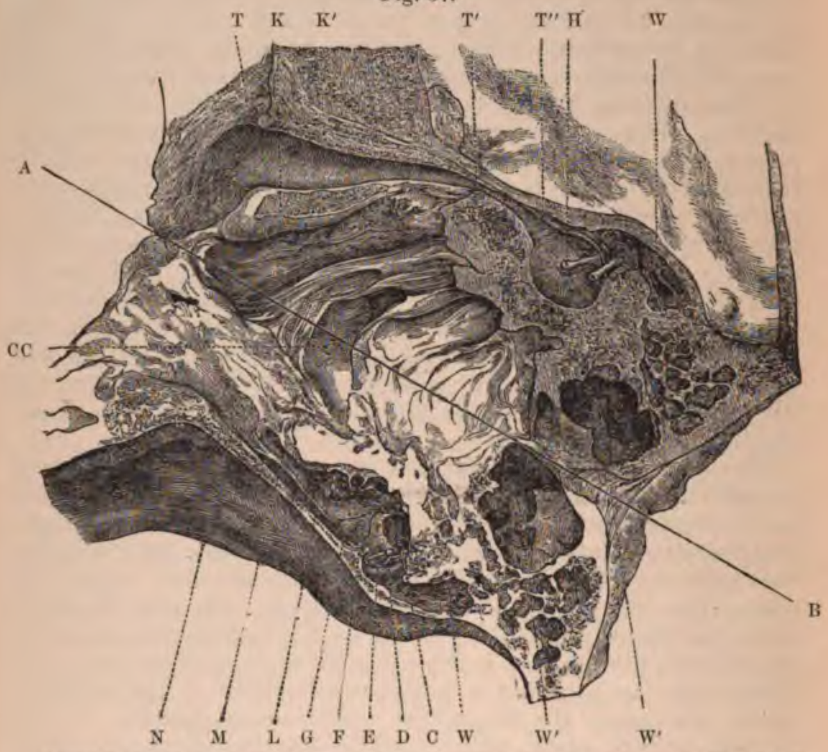
[1] Questions of Aural Surgery, p. 101. London, 1874.

[2] Die Ohrtrompete, Munich, 1870, p. 6.

Fig. 37.



VIEW OF THE ENTIRE RIGHT MIDDLE EAR, LAID OPEN BY AN INCISION FROM ABOVE DOWNWARD, THROUGH THE CENTRE OF THE CAVITY, PARALLEL TO THE LONG AXIS. (Gruber.)—Above the line A B, the outer half; below the line, the inner half.—T, T′, T″. Eustachian tube. T′. The isthmus. T″. The tympanic opening. K, K′. Section of the cartilage; between these points the groove of the so-called membranous part of the tube is seen, below which the muscles of the tube are seen in section. H. The manubrium of the malleus, with a remnant of the tendon of the tensor tympani. Behind the manubrium may be seen the descending process of the incus; above, the articulation of the malleus and the incus. Between the manubrium of the malleus and the shaft of the incus may be seen the chorda tympani running from behind and below, upward and forward, which also marks the edge of the folds of the membrana tympani. W. Entrance to the mastoid cells. W′. Large cavity in mastoid cells.

The inner half; below the line A B.—CC. Part of the petrous portion of the carotid canal (opened). N, M. Eustachian tube. L. Canal of the tensor tympani muscle. F. Rostrum cochleare with part of the tendon of the tensor tympani. G. Promontory on the inner wall of the tympanic cavity; on the posterior boundary the niche of the round window. E. Stapes. D. Transverse part of the Fallopian canal. C. Eminentia pyramidalis with the tendon of the stapedius muscle still attached to the head of the stapes. W. Entrance to the mastoid cells. W′. Mastoid cells.

When the muscles relax, the natural elasticity of the cartilage causes it to resume its original position, and the tube becomes narrower.

Moos coincides with the view respecting the action of the tensor veli upon the anterior hook of the tubal cartilage, but rejects the idea that the levator veli assists in widening the Eustachian tube.

By direct inspection of the pharyngeal end of the Eustachian tube, Dr. Michel[1] has observed that, at the act of swallowing, the velum palati rises and pushes a fold of mucous membrane into the tubal opening between the tubal ridge and the outer edge of the posterior nostril. At the termination of the act of deglutition the velum falls back to its original position and the mouth of the tube is freed from the above-named fold.

These observations of Dr. Michel have been confirmed by subsequent study of the faucial end of the Eustachian tube in a young man who had lost by necrosis all the osseous contents of the nasal cavities and the bony roof of the nose.[2] In this case the entire nasal cavity and the nasopharyngeal space were exposed to view, and the cavity from one tubal mouth to the other, with the insertion of the velum palati, could be seen at a glance. The observations already made by Dr. Michel were thus supplemented by watching the act of swallowing in this young man. It was found that during this act, two long vertical ridges form on the posterior pharyngeal wall behind the lower end of the tubal prominence. These produce an upward movement and project from 1 to 1¼ cm. above the surface of the velum, but leave a space about 1 cm. broad between them. In singing, instead of such ridges, moderately thick folds are formed. From the formation of these ridges Dr. Michel is led to suppose that the floor of the tube is pushed upward by the combined action of the levator palati and the pterygo-pharyngeus, the latter by its contraction and consequent thickening pushing upward the former muscle.

The tendency in swallowing, therefore, would seem to be to force the floor of the Eustachian tube upward and its two walls apart.

Dr. Fournié,[3] after careful experiments, has come to the following conclusions: 1. The Eustachian tube is always open and in direct communication with the air of the pharynx. 2. The tubal muscles, the peristaphylinus internus and externus, and the pharyngo-staphyline fascia, are intended by their contraction to shut and not to open the tube.

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[1] Das Verhältniss der Tubenmündung zum Gaumensegel am Lebenden betrachtet durch die Nase. Berlin. Klin. Wochenschr., 1873, 34.

[2] Neue Beobachtungen über das Verhalten der Rachenmündung der Tuba und über die Thätigkeit der Musculatur des Schlundkopfes. Berlin. Klin. Wochenschr., No. 41, 1875. See abstract by Dr. Zaufal, Archiv f. O., Bd xi. S. 60–63.

[3] Congrès de Reims. Revue Mensuelle de Laryngologie, d'Otologie, et de Rhinologie, No. 3, Oct. 1880.

Conjoint Physiology of the Eustachian Tube, Tympanic Cavity, and the Mastoid Cells.—According to the carefully conducted experiments of Mach and Kessel[1] on the functions of the tympanic cavity and the Eustachian tube, it is shown that sound-waves will produce the greatest effect when, in the middle ear, the following three conditions are maintained, viz.:

1. The Eustachian tube must, as a rule, remain closed.
2. It must, however, be opened occasionally for purposes of ventilation.
3. The tympanum should be in connection with large, irregular cavities.

These conclusions are based on the following observations and facts:

The length of most of the audible sound-waves is so great that the entire head of the hearer is, as it were, submerged in the wave of sound, and in the case of deeper sounds, all of the superficial parts are subjected to the same variations in pressure. If, then, the membrana tympani were exposed equally on both sides to the waves of sound, it could not be set into perceptible vibrations on account of this simultaneous and equal pressure on both its surfaces.

Therefore, these observers conclude that "the waves of sound will produce the best effects upon the membrana tympani when it is unexposed on one side to the sound-waves, *i. e.*, when the Eustachian tube is closed.

On the other hand, it must be remembered that a difference in the atmospheric pressure on both sides of the membrana tympani is a serious interference with the mobility of the membrane. Therefore, the Eustachian tube must be opened now and then in order to restore the equilibrium in the pressure of the air on each side of the membrane, which may have been interfered with by various physical causes.

The capacity of the tympanum must not sink below a certain limit if variations in pressure of a given amount are to produce vibrations of the membrana tympani of a corresponding amount; for if the capacity of the tympanum is small, then very slight excursions of the membrana tympani will produce considerable expansive power of the inclosed air, which will operate against further increase in the vibrations.

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[1] Die Function der Trommelhöhle und der Tuba Eustachii Sitzungsberichte der k. k. Academie d. Wissench., 1872. See also Archiv f. Ohrenh., N. F., Band ii, S. 116–121.

This is a very important circumstance in the consideration of the excursions produced by deep tones. In order that the latter may be received, the tympanum must have a certain depth and a generous capacity. Therefore the tympanum is in connection with the cavities of the mastoid process, and those of other portions of bone. A larger tympanum with perfectly regular outline and form would be impracticable from its great resonance. Therefore, the irregular, spongy, bony cavities, with which the ear is connected, appear to be of the greatest advantage.

SECTION III.

INTERNAL EAR.

CHAPTER I.

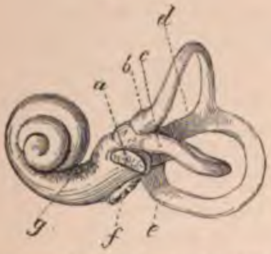
LABYRINTH AND AUDITORY NERVE.

ANATOMY.

The internal ear, sometimes called the labyrinth, is composed of a bony portion or case, and a membranous portion contained in the latter.

The bony portion of the internal ear consists of the vestibule, the central portion, with which the cochlea is connected anteriorly, and the semicircular canals posteriorly.

Fig. 38.

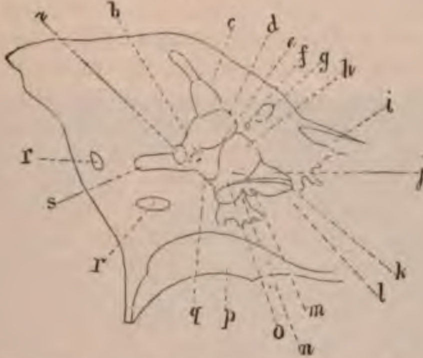


External View of a Cast of the Left Labyrinth. (Henle.)—*f*. Fenestra cochleæ or round window. *a*. Fenestra vestibuli, or oval window. *b*. Ampulla of superior semicircular canal. *e*. Ampulla of posterior semicircular canal. *d*. Common shaft of union of these two canals. *c*. Ampulla of the horizontal semicircular canal. *g*. Tractus spiralis foraminosus.

The Vestibule.—The vestibule is a small cavity situate just beyond the inner wall of the tympanum. This wall is common to both cavities, and in it is the oval window, into which fits the foot-plate of the small stirrup bone. A section of the vestibule parallel to its tympanic wall is round or elliptic, but a section at right angles to this, and running parallel to the floor of the tympanum, is in general of a pear shape, the point of which is directed forwards. This of course indicates that there is a general tendency on the part of the four walls of the vestibule to unite anteriorly near the cochlea. The average distance of the outer from the inner wall of the vestibule, is from 3 to 4 mm.; its long diameter, running between its anterior and posterior limits, is about 5 mm., as given by Henle.

On the inner walls are found two depressions separated by a narrow, sharp ridge; the anterior depression is the *recessus sphæricus* for the reception of the *sacculus rotundus*, and the posterior depression is the *recessus ellipticus*, in which lies the *utriculus*. The ridge between these grooves is the *crista vestibuli.*

Fig. 39.



Section of the Pyramidal Part of the Right Temporal Bone, through the Vestibulum Parallel with the Outer Wall of Latter; View of Inner Wall. (Henle.)—*a*. Common opening of the superior and posterior semicircular canals. *b*. Sinus sulciformis. *c*. Ampullar end of anterior vertical or superior semicircular canal. *d*. Recessus ellipticus. *e*. Crista vestibuli. *f*. Section of the small canal which conveys the branch of the vestibular nerve to the pyramid of the vestibule. *g*. Section of the facial canal. *h*. Recessus sphæricus. *i*. Canal of the tensor tympani. *j*. Scala vestibuli. *k*. Lamina spiralis. *l*. Scala tympani. *m*. Inner opening of the aquæductus cochleæ. *n*. Crista semilunaris. *o*. Recessus cochleæ. *p*. Fossa jugularis. *q*. Ampullar opening of the posterior vertical, or posterior semicircular canal. *r*, *r*. Sections of this canal. *s*. Posterior opening of the horizontal semicircular canal.

The latter finally terminates above the oval window, on the outer wall, in a sharp point named the pyramis vestibuli. Below, the crista vestibuli divides into two branches, the one skirting along the lower edge of the *recessus sphæricus*, and the other running backwards towards the ampulla of the posterior semicircular canal. These branches inclose the *recessus cochlearis* of Reichert. The recessus ellipticus is further bounded below by a shallow furrow, the *sinus sulciformis.*

The Ampullar Mouths of the Semicircular Canals.—On the upper wall of the vestibule, just above the recessus ellipticus, is the ampullar opening of the superior semicircular canal; in the angle between the posterior and inner wall near the inner opening of the aquæductus vestibuli, is found the ampullar opening of the common end of the superior and posterior semicircular canals. At about the same height in the centre of the posterior wall is the posterior opening of the horizontal semicircular canal. The lower opening of the posterior semicircular canal is in the angle formed by the union of the posterior, the inferior, and the inner wall of the vestibule. The anterior ampullar mouth of the horizontal semicircular canal is in the outer wall between the oval window and the ampulla of the superior semicircular canal.

Maculæ Cribrosæ.—These are groups of fine microscopic openings through which the nerves enter the vestibule. The superior group is found at the upper spinous termination of the crista vestibuli; a second group is in the recessus sphæricus, and a third is situate at the ampullar opening of the posterior semicircular canal. Through the superior cribriform spot nervous filaments pass to the utriculus and to the ampullæ of the superior and the horizontal semicircular canals, through the middle cribriform spot nerves pass to the sacculus, and through the lower spot the ampulla of the posterior semicircular canal is supplied.

Reichert has described a fourth cribriform spot, in the upper part of the recessus cochlearis, near the origin of the lamina spiralis. This gives admission to a filament from the smaller branch of the cochlear nerve, which is distributed to the septum between the sacculi in the vestibule.[1]

The Cochlea.—The bony cochlea may be described very briefly as an osseous canal twisted spirally two and a half times about a bony pillar. This shape closely resembles that of a snail-shell, and has suggested the name of the cochlea.

The bony cochlea may be divided into the spiral canal, modiolus, and the lamina spiralis ossea, which, projecting from the modiolus into the calibre of the canal of the cochlea, terminates above at the helicotrema in what is named the hamulus.

The Canal of the Cochlea.—The cochlear canal starts at the extreme outer and lower corner of the vestibule, and winding outward and forward makes in its first half turn the promontory of the inner wall of the tympanum.

Each turn of the cochlea is shorter than the previous one, and rising above and beyond it outwardly forms the peculiar resemblance indicated by its name. The height of the cochlea is equal to the diameter of its base, and measures about 4 or 5 mm. The entire length of the cochlear canal is from 28 to 30 mm.

The *modiolus*, which may be considered as representing the axis of the cochlea, is nearly in the axis of the porus acusticus

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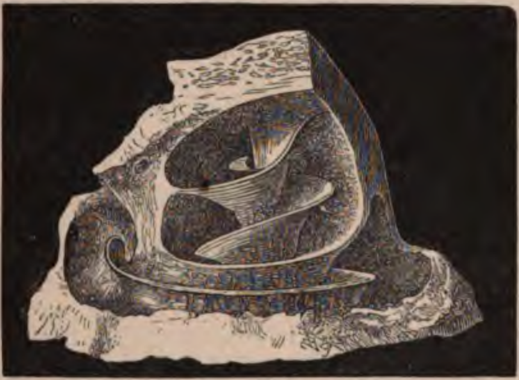
[1] Henle, op. cit., p. 760.

internus and about at right angles to the long diameter of the pyramid of the petrous bone. The point of the cochlea is directed outward, forward, and downward. The latter part of the cochlea, the cupola, is separated by a thin plate of bone from the canal of the tensor tympani muscle, while in front the coils are very close to the carotid canal. The diameter of the canal of the cochlea is about 1 mm. at its widest part; from the beginning of the last half turn it becomes much smaller. A transverse section of the cochlear canal varies in shape, being sometimes elliptical and at others semicircular. Its more common shape is that of a segment of a circle, the point of which is directed towards the axis of the cochlea. The thickness of the dividing wall between the turns of the cochlea is 0.3 mm. at the lower turn, and 0.03 mm. at the upper part of the canal.

Fig. 40.



OSSEOUS COCHLEA LAID OPEN. (Magnified 4 diam.: Henle.)

The Modiolus and Lamina Spiralis Ossea.—The general shape of the modiolus is pyramidal. At its base the diameter is 2 mm., at the apex 0.5 mm., and its height is 2.50 mm.

The modiolus is not only the bony axis about which the cochlear canal is twisted, but it is traversed by numerous canals for the transmission of the branches of the cochlear nerve, which is finally distributed like fringe on a bony shelf running spirally around the modiolus and projecting into the canal of the cochlea. This bony shelf is the lamina spiralis ossea.

The Scalæ.—The lamina spiralis ossea divides the canal of the cochlea into its scalæ. The upper one of these is the scala vestibuli, beginning at the vestibule and continuing to the helicotrema; the lower one, the scala tympani, may be said to begin at the helicotrema and end at the round window.

The general relation of the spiral bony lamina to the scalæ, and the relation of the latter to each other, will be understood, perhaps, better if the reader imagines himself starting from the vestibule along the upper surface of the bony partition between the scalæ, and continuing until he reaches, at the helicotrema, the sharp hook-like end of the bony lamina. At this point he must imagine that what has been the floor of the scala vestibuli now becomes the upper surface or roof of the scala tympani.

If the scala tympani be traversed, in imagination, two and a half turns will reach the membrane of the fenestra rotunda.

The lamina spiralis ossea forms only part of the division between the scalæ; as it does not pass as a bony septum from the modiolus to the opposite wall of the canal, the separation of the two scalæ from each other is not complete until the soft parts are added to the osseous structures. The lamina spiralis is thicker at its lower end than at the top of the modiolus. At the former point it may amount to 0.3 mm., but at the upper part, only to 0.15 mm. The width of the lamina spiralis is 1.2 mm. at the lowest part, and 0.5 at the upper part.

The Semicircular Canals.—To the posterior part of the vestibule are attached the three semicircular canals. These are named, according to their positions and planes, the superior, the posterior, and the horizontal semicircular canal.

Although there are three distinct canals, there are but five openings from them into the vestibule. This is due to the fact that two of the canals, the superior and the posterior, are joined to a common shaft just before they reach the vestibule. The position of these openings on the wall of the vestibule has been described already (p. 121). At one end, each of the canals has a dilated portion, its ampullar enlargement. These enlargements contain soft parts of similar name and shape, the ampullæ of the membranous semicircular canals. The latter will be described later.

Dimensions of the Semicircular Canals.—The length of the posterior semicircular canal is the greatest of the three, amounting to 22 mm. The length of the superior canal is 20 mm. and that of the horizontal canal is only 15 mm., as shown by Hushke and Henle. The common shaft of the superior and posterior canals is from 2 to 3 mm. long.

A transverse section of these canals is elliptical. The long diameter is to the shorter as 2 : 3 or 3 : 4. The longer measures, in man, from 1.3 to 1.7 mm. (Henle).

Ampullar Enlargement.—The shape of the ampullæ is that of an ellipsoid. The ampulla of the superior and of the posterior canal is sharply defined from the rest of the canal as well as from the vestibule by a ridge, but the horizontal semicircular canal glides gradually into its ampullar end. The height of the ampulla, in the centre, is about 2.5 mm., not quite as great as the longer diameter of its calibre.

The Planes of the Semicircular Canals.—The superior and the posterior canals are in vertical planes at right angles to each other. The horizontal semicircular canal, as its name shows, is in a plane at right angles to that of both the others. The top of the superior canal points upwards, making thus a visible ridge on the anterior surface of the petrous bone. The top of the posterior canal points directly backwards, as does that of the horizontal semicircular canal.

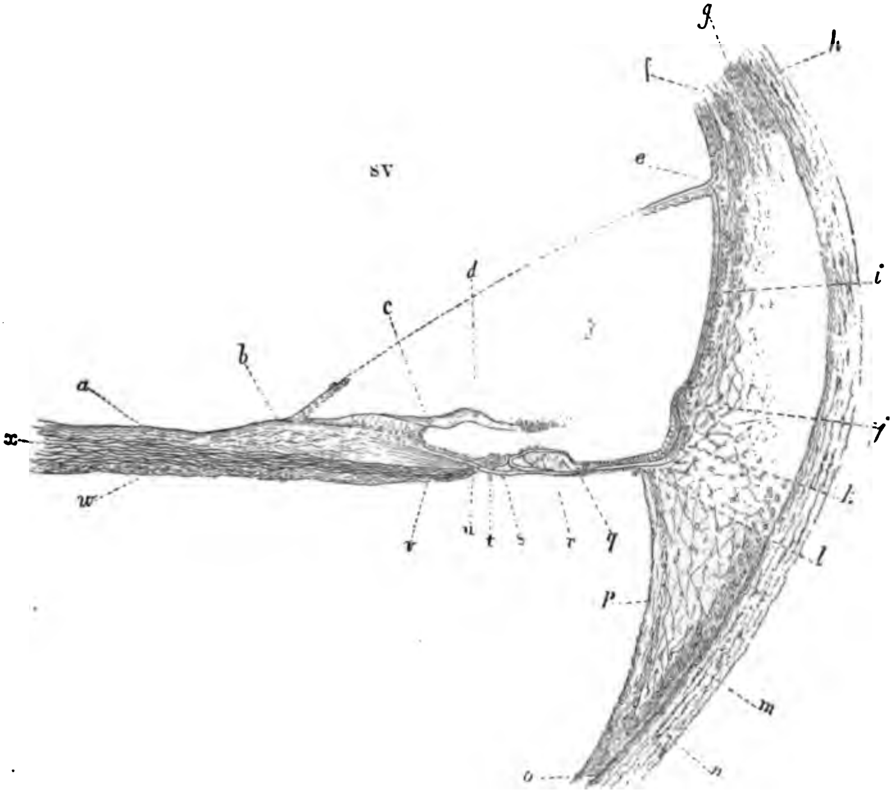
Soft Parts of the Cochlea.—If a transverse section of the canal of the cochlea be examined under the microscope, the manner in which the canal is subdivided into its scalæ will be seen. This division is first indicated by the projection of the lamina spiralis ossea into the calibre of the canal. The free end of this bony shell would, therefore, form a good point for beginning the consideration of the topographical arrangement of the different parts of the cochlea.

Soft Parts of the Lamina Spiralis Ossea.—Upon the upper surface of the lamina spiralis ossea is placed the vestibular lamella, and upon the under surface is placed the tympanal lamella of the lamina spiralis ossea. Through the bone lying between these lamellæ runs the nerve on the way to its termination at the organ of Corti and the ciliated cells, a description of which will follow later.

The tympanal lamella is continued in the same plane, directly across from the under edge of the lamina spiralis ossea to the opposite wall of the cochlear canal. Here it is joined to the latter at the thickest point of a cushion of connective tissue called the ligamentum spirale of Henle. The division of one scala from the other is now complete, by the formation of this, the *membrana basilaris.* This membrane does not seem to be very elastic, according to recent observations of Waldeyer. The upper or vestibular lamella of the lamina spiralis ossea is the thicker of the two. About half way between its origin and the point of the spiral bony lamina, the vestibular lamella is thickest, from which point it seems to taper to the edge of the bony shelf on which it lies.

At this thick part there rises a delicate membrane, the mem-

Fig. 41.



Transverse Section of the First Coil of the Cochlea of a Child one and a half year old. (Magnified 100 diam.: Waldeyer.[1])—The membrana tectoria is sketched from another preparation of the same cochlea. SV. Scala vestibuli. ST. Scala tympani. *y.* Ductus cochlearis. *a.* Vestibular lamella of the lamina spiralis ossea. *w.* Tympanal lamella of same. *x.* Cochlear nerve. *h, n.* Osseous wall of cochlea. *g, o.* Periosteum. *f, p.* Cushion of connective tissue (lig. spirale of Kölliker) partially loosened from the bony wall, and thickened near the ductus cochlearis, into a special fibrous mural layer for the latter. *i.* Stria vascularis. *o.* Point of union between the periosteum and the cushion of connective tissue. *l.* Lig. spirale; *Henle. j.* Lig. spirale accessorium, with the vas prominens. *k.* Sulcus spiralis externus. *b, e.* Reissner's membrane; only the two end-pieces shown; the rest indicated by a dotted line. *b, c.* Crista spiralis. *c.* Its most prominent part in profile; the so-called "auditory teeth." *d.* Membrana tectoria. *v.* Sulcus spiralis internus. *u.* Point of entrance of the nerve (Habenula perforata). *u, l.* Membrana basilaris. *u, q.* Corti's organ. *c, q.* Zona denticulata. *t, r.* Zona arcuata. *q, l.* Zona pectinata with epithelium. *t.* Region of the inner ciliated cells. *s.* Thinnest part of the membrana basilaris under Corti's organ. *r.* Region of outer ciliated cells.

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[1] Stricker's Handbuch, etc., p. 922.

brane of Reissner, which springs across the scala vestibuli, and is fastened at a point on the opposite wall of the cochlea about 40° above its starting-point. This is a most important membrane, since it forms the upper or vestibular boundary of the ductus cochlearis.

The membrane of Reissner is said to consist of a thin connective-tissue basement lamella, rich in vessels. On its vestibular surface large-celled, serous epithelium is found, and on its tympanal surface a single layer of regularly arranged, cubic epithelial cells.

It will now be seen that the cochlear canal is really subdivided into three canals—the scalæ already named and the ductus cochlearis which is formed at the expense of part of the scala vestibuli. The ductus cochlearis may, therefore, be said to lie upon the membrana basilaris above the grand division-line of the scalæ, and should indeed be imagined as slipped into a triangular-shaped canal lying between the scalæ at their outer edges. The scalæ are lined with periosteum covered with large, flat epithelium. They are filled with perilymph, and are in communication with each other only at the helicotrema in the cupola of the cochlea.

The ductus cochlearis is not in communication with them at any point; it begins and terminates in so-called blind ends. The scala tympani ends at the membrane of the round window, but the scala vestibuli is in free communication with the vestibule.

Crista Spiralis.—From the point where the membrane of Reissner is attached to the vestibular lamella of the lamina spiralis ossea, there extends a crest or ridge of connective tissue and developed epithelium called the crista spiralis, the serrated edge of which is called by some anatomists, "aural teeth."[1] From this free peculiar edge rises the membrana tectoria, which extends as far as the beginning of the organ of Corti.

The space between the crista spiralis and the point of junction between the lamina spiralis ossea and the membrana basilaris, is called the sulcus spiralis internus (*v*, Fig. 41).

Corti's organ extends from the junction of the membrana basilaris and lamina spiralis ossea to a middle point on the former membrane. From this point the epithelial lining of the ductus cochlearis pursues a less complicated course outward and upward over the wall of the duct.

Just above the attachment of the membrana basilaris to the outer wall, at the spiral ligament, there may be seen a prominence known as the accessory spiral ligament, but which really seems to form a passage for a vessel named the *vas prominens.* Between these two points lies the sulcus spiralis externus.

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[1] Gehörzähne of Hushke.

Above the vas prominens, between it and the upper and outer attachment of Reissner's membrane, is found the *stria vascularis.*

Habenula Perforata and the Zonæ.—The habenula perforata is situate at the extreme thin edge of the osseous spiral lamina, and gives exit to the nerve-branches. The *zona denticulata* extends from the crista spiralis to the outer end of Corti's organ; the *zona arcuata*, from the inner to the outer ciliated cells; and the *zona pectinata* extends from the outer boundary of the organ of Corti to the spiral ligament of Henle. These names are descriptive of the appearance of the region extending from the crista spiralis to the ligamentum spirale, when viewed from above.

According to the investigations of Waldeyer, three varieties of tissue can be discerned in the first stages of development of the cochlea. At that time the most external layer is a cartilaginous mass connected with the base of the skull. In this mass is a collection of embryonal mucous tissue, within which is imbedded the epithelial labyrinth vesicle. From the latter, which at last becomes the sacculus, a hollow sprout, lined with epithelium, grows before the eighth week, and pushing its way into the mucous tissue, is forced by the surrounding cartilage to *curl itself up into a spiral shape.* This is the first trace of the ductus cochlearis. At one point the cartilaginous capsule is not closed, and here the cochlear branch of the auditory nerve enters.

The bony portion of the cochlear capsule, is divided into a compact inner layer, a tabula vitrea, and the more porous modiolus and lamina spiralis. In the latter is found the canalis ganglionaris, in which lies the spiral ganglion of the auditory nerve.

The inner surface of the periosteum of the canal is covered with a layer of simple, large, flat, nucleated cells, similar to those found on the surface of serous membranes.

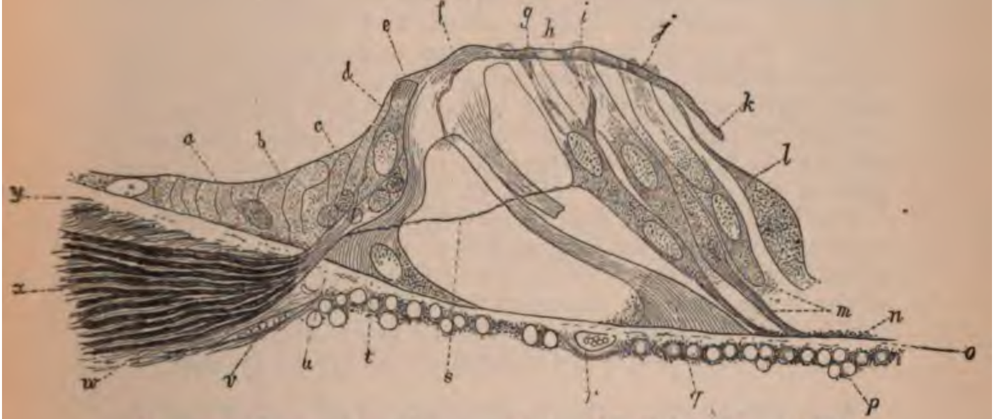
Ductus Cochlearis.—From the foregoing description of the three divisions of the cochlear canal it must have been seen already that the most important of these is the ductus cochlearis. It is indeed from the epithelial lining of this important capsule that the highly organized contents of the cochlea are developed, so as to be the recipients of the terminal filaments of the auditory nerve, after it passes the habenula perforata and reaches the cavity of the ductus cochlearis.

The most important of these structures is the organ of Corti.

The Marquis of Corti[1] was the first to describe this apparatus, and it has from that time justly borne his name. Kölliker and Deiters subsequently enriched the knowledge possessed respecting this important apparatus of the internal ear.

The best treatise on the structure of the cochlea and the distribution in it of the auditory nerve has been written by Prof. Waldeyer.[2] Dr. Gottstein, his colaborer, has added the most important facts concerning the ultimate distribution of the auditory nerve to the outer ciliated cells.

Fig. 42.



TRANSVERSE SECTION OF THE ORGAN OF CORTI. (Magnified 800 diam.: Waldeyer.)—*y*, o. Homogeneous layer of the membrana basilaris. *n*. Vestibular layer of the same, corresponding to the radii of the zona pectinata. *p*. Tympanal layer with nuclei, granular cell-protoplasm, and transversely cut connective-tissue fibrillæ. *y*. Labium tympanicum of the crista spiralis. *w*. Continuation of the tympanal periosteum of lamina spiralis ossea. *u*. Thickened origin of the membrana basilaris immediately beyond the point of entrance of the auditory nerve *b*. *r*. Vas spirale. *v*. Bloodvessels. *x*. Nerve fasciculus. *a*. Epithelium of the sulcus spiralis internus. *d*. Inner ciliated cell. *c*. Its basilar process. About the latter and above the point of entrance of the nerve are some cells and fine, granular matter in which the nerve-fibrils are distributed (granular layer). *e*. Inner part of the capital of the inner pillar and the point where the cilia of the inner ciliated cells are situate. *f*. Point of junction of the arches; the body of the outer pillar is severed in the middle; behind it appear the body and base of the next pillar at *q*. *t*. Base with part of the granular protoplasm of the inner pillar. *g*, *i*, and *j*. Three outer ciliated cells. *m*. Basilar part of two other ciliated cells. *l*. Hensen's supporting cell. *e*, *k*. Lamina reticularis. *s*. Nerve-fibril distributed to the first ciliated cell, *g*, and traceable through the arch as far as the point of entrance of the auditory nerve at *b*.

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[1] Von Siebold and Kölliker's Zeitschr. f. Zoölogie, 1851.

[2] Stricker's Manual of Physiology.

Organ of Corti.—The position on the membrana basilaris occupied by the organ of Corti has already been pointed out. (Fig. 41, *u–q*.)

An idea of the general structure and appearance of this wonderful central portion of the ductus cochlearis can be gained by consulting Fig. 42.

The Pillars and Arches of Corti.—Upon the upper or vestibular surface of the membrana basilaris are two sets of pillars, an inner and outer row, uniting above and forming a series of arches. The pillars, like the arches, are named after Corti. They are about 3000 in number, according to Kölliker. A head, head-plate, foot, and body are parts into which anatomists have divided the pillars. At the junction of the pillars, the head of the outer is fitted into a depression between the head and head-plate of the inner pillar. (Fig. 42, *f*.)

The kind of tunnel thus formed by the arches of Corti is triangular in outline, the longest side of which corresponds to the membrana basilaris. This tunnel extends over the entire length of the lamina spiralis almost to the end of the hamulus, as described by Waldeyer. As a rule, the height and width of the arches increase towards the hamulus, as shown by Hensen.

Inner Ciliated Cells.—On the inner side of the arched roof thus formed is found the single row of inner ciliated cells. The latter are lost at their lower end finally, in what is termed the "granular layer." Their upper ciliated ends are received into corresponding head-plates of the inner pillars. Their cilia, arranged in dense tufts or plots, are extremely stiff and strong.

The Outer Ciliated Cells. — There are five rows of the outer ciliated cells. They are arranged in parallel rows beyond the row of the external pillars, and underneath the membrana reticularis.

The Membrana Reticularis.—The membrana reticularis, as its name indicates, is a net-like structure. It is one of the most complicated parts of Corti's organ, extending from the junction of the pillars to the so-called support-cells at the outermost row of the ciliated cells. Into the meshes of this delicate reticulate membrane, fit the tufts of cilia of all the outer ciliated cells. A profile view of this arrangement can be seen in Fig. 42, at *i* and *j*.

The Surface of the Membrana Reticularis.—Viewed from above, the membrana reticularis presents not only a very beautiful, but an equally complex appearance. It will be seen that the ciliated cells occupy alternate openings in the mesh of the reticulate membrane in both directions, thus giving a checker-board arrangement to the ciliated tufts and the intermediate spaces. To the former, the framework supporting the cilia, the name *ring* has been applied by Böttcher, and the finger-shaped interspaces have been called the *phalanges* by Deiters. The latter are filled out by a delicate membrane, according to Waldeyer. Over the entire organ of Corti, close to the membrana reticularis, is placed the membrana tectoria or Corti's membrane.

Membrana Tectoria.—Of this membrane, Waldeyer states that it begins immediately at the point of attachment of Reissner's membrane on the crista spiralis in the form of an immeasurably fine layer, covers the crista, while lying close to it, and at the same time increases greatly in thickness. It attains its greatest thickness in the sulcus spiralis internus, and terminates, as shown by Hensen, Gottstein, and Waldeyer, in a free and extremely delicate edge in the neighborhood of the outermost row of ciliated cells. (See Fig. 41, *d.*)

The constituent elements of Corti's organ have now been described as briefly and in as condensed a way as possible. Of this wonderful organ, Waldeyer says that, if there be left out of consideration the peculiarities of the inner ciliated cells, the apparently complicated structure of Corti's organ reveals really a simple plan. Several rows of cylinder-cells (double cells) are arranged in regular order on a broad zone of the spiral shelf. These rows are parallel to each other, and are held firmly in their position between two membranous boundaries, the membrana reticularis and the membrana basilaris. Two sets of these cylinder cells, the pillar cells, become developed for the purpose of forming a firm arch of support for the whole. Specially worthy of note is the fixation of the outer ciliated cells, which, by means of processes and their head-piece, are immovably held between the membrana reticularis and the basilar membrane. These cells, together with the pillars of Corti, are the exclusive peculiarity of man and other mammals. To this apparatus, *i. e.*, to its peculiar ciliated cells, the terminal filaments of the auditory nerve are directly sent.

The Auditory Nerve; Origin and Distribution.—According to the investigations of Stieda in 1868, with whom Waldeyer agrees, the auditory nerve springs by two roots from the medulla oblongata. The fibres of one of these are more delicate than those of the other. It originates from a ganglionic nucleus on the floor of the fourth ventricle. The second root, which is said by Stieda to contain larger axis-cylinders than any other nerve, springs from a special large-celled ganglionic nucleus in the crus cerebelli. This root acquires, soon after it leaves the medulla, a small ganglion, like one of the posterior roots of the spinal cord. Both roots soon unite into a common trunk, but divide again in the porus acusticus internus, into two branches, the *vestibular* and *cochlear branches.*

Vestibular and Cochlear Branches of the Auditory Nerve.—The first contains a small ganglion, intumescentia ganglioformis Scarpæ, and divides into the ampullar branches and those for the utriculus and the sacculus.

The cochlear branch, which is by far the larger of the two, gives off a small fasciculus to the septum membranaceum between the sacculus and the utriculus, and to the macula cribrosa, and then enters the first turn of the lamina spiralis, from which point it continues its course throughout all the windings of the spiral lamina.

Ampullar Branches.—Duval and Laborde[1] showed that some of the fibres of the auditory nerve originate in a collection of motor cells in the bulb, and further, that these fibres are continued in the inferior cerebellar peduncles. The conclusion, therefore, is that there are two sorts of fibres in the auditory nerve, viz., sensory and motor, and the branch possessing the latter function sends fibres to the ampullæ as well as to the cerebellum, and thus may be explained the reflex phenomena of disturbed equilibrium, from irritation in the ampullæ and semicircular canals.

Inner and Outer Nerve-ends of the Cochlear Branch.—The ultimate fibres of the auditory nerve in the cochlea are named the inner and the outer terminal filaments, in accordance with their distribution to the inner and outer hair-cells.

According to Waldeyer, both sets of fibres, as they emerge from the openings in the lamina spiralis ossea, pass through the "granular layer" which lies directly over their point of exit. The inner nerve-fibres then pass directly to the inner hair-cells. These fibres are large, and are considered as true axis-cylinders. The outer nerve-fibres are distributed, as shown by Gottstein, between the pillars of Corti, at about half the height of the arches, to the inner row of the outer hair-cells, and perhaps to the more distant rows.

The origin of the auditory nerve, being so near the origin of the pneumogastric nerve, would help to explain the sympathy which seems to exist between an aural disease and the respiratory and the digestive tracts.

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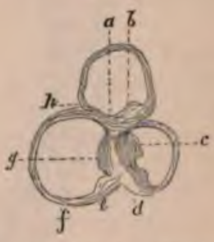
[1] De l'oreille, etc., Dr Gellé. Paris, 1881, p. 323.

There also seems to be a sympathy between the ear and the emotions. May not cases of apparently hysterical deafness be traced to some such central nervous connection?

Soft Parts of the Vestibule and Semicircular Canals; the Membranous Labyrinth.—Since, in the consideration of the osseous structure of the internal ear, all of the latter has been comprised under the name of labyrinth, an analogous term might be applied to all of the soft structures of the internal ear considered as a whole. But Rüdinger, who has written the best treatise on the subject, limits the term "membranous labyrinth" to the sacculi and the membranous semicircular canals. In this sense, therefore, the term shall be used in the consideration of the soft parts contained in the vestibule and bony semicircular canals.

Fig. 43.



Membranous Labyrinth of Man. (Rüdinger.)—*d.* Horizontal semicircular canal. *e.* Superior semicircular canal. *b.* Posterior semicircular canal. *h.* Canalis communis. *a.* Ampullar-like termination of the horizontal semicircular canal. *g.* Utriculus. *c.* Sacculus rotundus.

The membranous labyrinth, *i. e.*, the sacculi and the semicircular canals, is now considered an important part of the perceptive auditory apparatus. Rüdinger[1] has shown that these parts of the internal ear are in direct contact with the osseous or cartilaginous structures containing them, and that, therefore, they do not float, as heretofore supposed, entirely free in the perilymph.

The periosteum, lining the bony cavity containing these membranous parts, is a moderately thick layer of connective tissue, with some fine elastic fibres.

The Sacculi.—Of the sacculi, the utriculus is more closely connected to the inner wall of the vestibule than is the sacculus rotundus. The two sacculi occupy two-thirds of the cavity of the vestibule. The utriculus extends further outward towards the tympanum, but neither of them touches the side of the vestibule which receives the base of the stapes, *i. e.*, they do not touch the outer wall of the vestibular cavity.

The Membranous Semicircular Canals.—These are fastened to the convex side of the bony canals by means of stout connective-tissue fibres, which are called by Rüdinger the *ligamenta labyrinthi canaliculorum.* These constitute the true support of the membranous canals. Sometimes there are two or more of these connective-tissue stays, so arranged as to simulate under the microscope transverse sections of small canals. But they are to be considered simply as part of the support of the membranous semicircular canals. (Fig. 44, *e.*)

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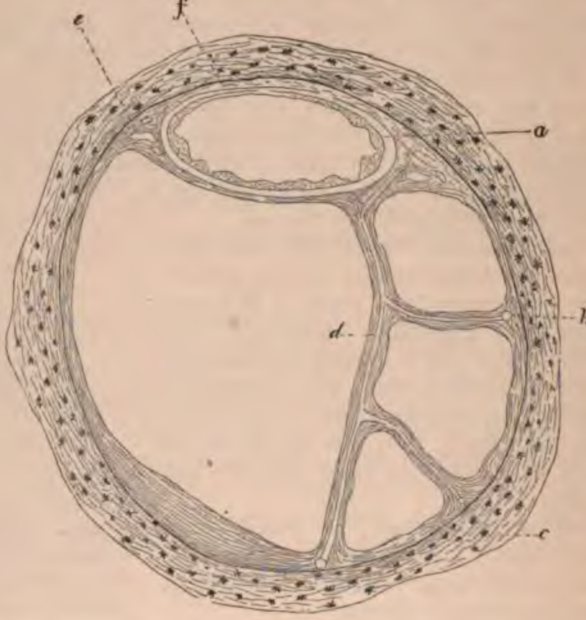
[1] Das häutige Labyrinth. Stricker's Handbuch. Leipzig, 1872.

Fig. 44.



Transverse Section of the Bony and the Membranous Semicircular Canal of Man. (Rüdinger.)—*c.* Bony wall. *d.* Fasciculi of connective tissue inclosing vessels. *b.* Junction of fibres with periosteum. *a.* Membranous semicircular canal with its three layers. *e.* Ligamenta canaliculorum with their lacunæ. *f.* Junction of the membranous semicircular canal with the periosteum.

Another set of connective-tissue fibres, passing from the periosteum to the free surface of the labyrinth wall, are for the purpose of supporting the bloodvessels as well as supplying points of fixation for the free wall of the membranous labyrinth.

Hasse has thought that he could demonstrate the existence of serous membrane in the labyrinth of the frog, but Rüdinger has not been able to satisfy himself on this point.

The wall of the membranous semicircular canals has an unequal thickness, being 0.016 mm. at the point of contact with the periosteum; it is thickest (0.060 to 0.080 mm.) at the point of junction with the ligamenta labyrinthi canaliculorum. The canal wall is composed of four layers in the following order from without, inward, viz.: 1. A layer of connective tissue. 2. Hyaline tunica propria. 3. Papilliform prominences; and, 4. The epithelium.

The external layer possesses all the qualities of connective tissue with numerous cells. When the entire membranous semicircular canals, removed from their connection with the periosteum and ligaments, are subjected to examination, another network is found, closely resembling nerves and ganglia. But it is as yet very uncertain whether these are nerve-elements, since the existence of nerves in the membranous semicircular canals is doubtful.

The tunica propria is of unequal thickness in the semicircular canals, but in the utriculus it is of uniform as well as great tenuity.

The papilliform prominences on the inner surface of the tunica propria are considered by Rüdinger as normal structures in the adult human being. (Fig. 44, *a.*)

They are so constant in their occurrence that their absence and not their presence is to be considered pathological. They are confined to certain parts of the wall of the canal, are varied in size and shape, and pass imperceptibly into the tunica propria, of which they must be considered a part. They attain their greatest size at the point of insertion of the ligamenta canaliculorum. They are not found on that portion of the tunica propria corresponding to the part of the canal in contact with the bony wall, and are but slightly developed on the free side of the membranous canal.

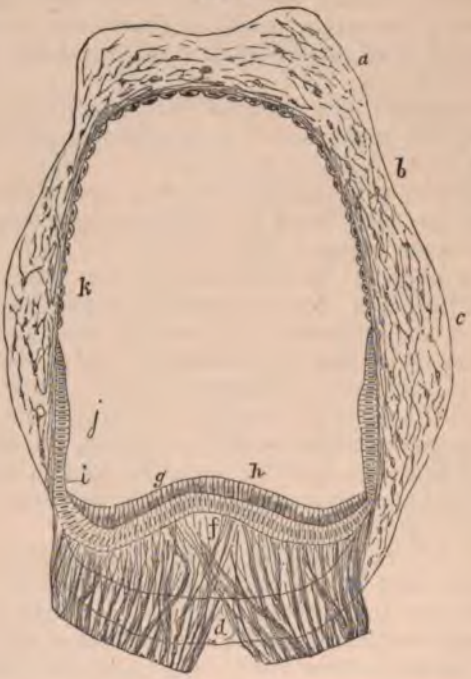
The papillæ are covered with pavement epithelium, which is easily detached; and hence, perhaps, the assertion on the part of some observers, that epithelium does not exist at this point. These bodies are not found in the sacculi, nor at that part of the semicircular canals where the latter pass into the utriculus. Although these bodies may not be found in the new-born child, and are considered pathological by some, Rüdinger says he has never failed to find them in the adult human being.

The absence of epithelium, and the reaction between these bodies and iodine, have been urged as proof of their starchy nature. But Rüdinger has demonstrated that epithelium can always be shown to be present with these bodies by the application of the proper tests; and as far as iodine is concerned, it gives the peculiar reaction alluded to, in common with the tunica propria and many other tissues, in which the presence of starch has *never* been proven.

In conclusion, the same investigator says their round form can never be adduced as a proof that they are amyloid, and if the inner surface of the membranous canals possesses a secerning nature, these bodies will supply a larger surface demanded by such a function. These papilliform bodies are not found in the lower mammals.

Sacculi and Ampullæ; inner Surface.—On the inner surface of these organs there is found a constant and peculiar yellowish

Fig. 45.



Transverse Section of an Ampulla of a Fish: Floor and Wall. (Rüdinger.)—*a*. Roof of ampulla. *b*. Thin spot on its wall. *c*. Thick portion of wall. *d*, *e*, and *f*. Floor with the nerves. *g*. Nerve-epithelium. *h*. Acoustic cilia. *i*. Transition point between floor of ampulla and, *j*, planum semilunare. *k*. Flat epithelium.

epithelium provided with cilia. There is also found a reduplication of the tunica propria extending into the cavity of the ampullæ to which the name of *crista acustica* has been given by Max Schultze. A similar projection in the sacculi is called by the same authority the *macula acustica*.

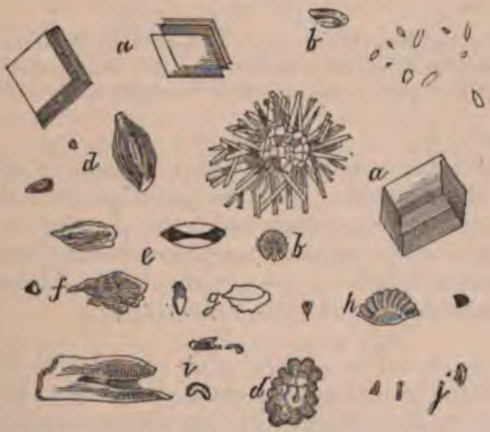
Every branch of the acoustic nerve, going to the ampullæ, after dividing into two flat fasciculi supplied with ganglion cells, passes through the tunica propria, and is then distributed to the ciliated epithelium of the crista acustica.

Planum Semilunare.—At right angles to each end of the crista acustica, extending along the walls of the ampullæ, there is an elevation on the epithelial layer, named the planum semilunare.[1] To this also, some of the terminal filaments of the auditory nerve are conveyed, as shown by Rüdinger.

The epithelial layer in the sacculi is thinner than that in the ampullæ. There are several varieties of epithelium in this layer. But here, too, ciliated cells are found, to which nerve-filaments are sent.

The Otoliths.—In the endolymph of the sacculi there are found small crystals of carbonate of lime, called Otoliths.

Fig. 46.



OTOLITHS FROM VARIOUS ANIMALS. (Rüdinger.)—*a.* Scymnus lichia (Leydig). *b.* Cyprinus, carpio or carp. *c.* Goat. *d.* Roach; fish. *e.* Wood-grouse (Leydig). *f.* Pike. *g.* Pterois volitans (Breschet). *h.* Sea-devil. *i.* Mackerel. *j.* Herring.

Some observers have found otoliths in the endolymph of the semicircular canals and in that of the cochlea, but these are generally considered exceptional occurrences.

Henle, after treating the otoliths with acids, thought he detected a cartilaginous remnant, to which the name of otolith cartilage is given. They are, according to Rüdinger, large and few in reptiles, but small and numerous in man and other mammals.

The Topographical Arrangement of the soft Parts of the Internal Ear.—By consulting Fig. 47, the general relations between the soft parts of the internal ear may be learned. It will be seen that the sacculus rotundus pertains more to the ductus cochlearis than to the utriculus and the rest of the so-called membranous labyrinth. The link between the sacculus and the ductus cochlearis is the canalis reuniens of Hensen.

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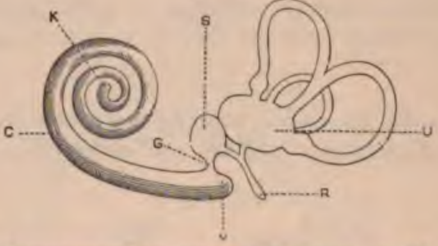
[1] Steifensand, 1835.

Fig. 47.



A Scheme of the Membranous Labyrinth of Mammals. (Waldeyer.)—U. Utriculus with the membranous semicircular canals. S. Sacculus. R. Aquæductus vestibuli. G. Canalis reuniens. C. Ductus cochlearis, with V. Vestibular cul de sac, and K. Cul de sac of the cupola.

The aquæductus vestibuli is the roundabout way from the utriculus to the sacculus. Of this peculiar duct more will be said hereafter. The utriculus, as shown in the diagram, is the cavity with which the membranous semicircular canals and their important ampullæ are in close connection. The entire membranous labyrinth is filled with endolymph.

The Endolymph.—The general plan upon which the endo- and perilymph of the inner ear are renewed, has been best explained by Dr. Hasse, of Würzburg.[1] He has shown that all vertebrates possess a duct, which originates in the vestibule; and in all animals, with the exception of the plagiostomes, in which it passes directly to the surface of the skull, this duct enters the cavity of the cranium, and there terminates either in a closed sac at the confines of an epicerebral lymph-cavity or opens into the same. This is the *ductus endolymphaticus* or the *aquæductus vestibuli*, with the *saccus endolymphaticus*, the former of which arises from the sacculus rotundus in most vertebrates, and conveys endolymph to the membranous labyrinth.

Physiological Functions.—Dr. Hasse has suggested three probable functions of the aquæductus vestibuli, or the endolymphatic duct.

1. The endolymphatic duct and its sac are the source of the endolymph in embryonal life. In this capacity, the sac plays the part of a kind of gland.

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[1] Anatomische Studien, No. xix. p. 768.

2. In adult life, this duct may act as a conveyer of new material to the endolymph, either by endosmosis from the epicerebral cavities in those instances where the saccus endolymphaticus is closed, or by means of a direct current where the saccus is open.

3. It may be supposed that the sac is useful as a reservoir for the liquor endolymphaticus, when the intralabyrinthal pressure attains an excessive height. By the reception of the fluid into this sac, the pressure would be reduced in the labyrinth.

A very practical deduction is made by Dr. Hasse, respecting the ductus endolymphaticus. Every increased or diminished pressure of the cerebro-spinal fluid in the subarachnoid cavity will make itself felt by continuity through the saccus and the ductus endolymphaticus, in the interior of the auditory apparatus, in the endolymphatic cavity, and upon the terminal filaments of the auditory nerve. Thus may be explained the impairment of hearing for high notes when the pressure in the labyrinth is increased.[1] Furthermore, pathological processes in the subarachnoid space are conveyed either by continuity or contiguity through the saccus and ductus endolymphaticus, into the interior of the labyrinth, and *vice versâ*, the latter being the rarer, from the deep-seated position of the inner ear. Thus, every alteration in the chemical constitution of the cerebro-spinal fluid, necessarily produces a change in the liquor endolymphaticus, which alteration may exercise some influence in the occurrence of subjective acoustic perceptions, but in any event, must change the composition of the endolymphatic fluid.

The Perilymph.—The perilymph is poured into the labyrinth from the subarachnoid space through the foramina acustica, and leaves the labyrinth by means of the aquæductus cochleæ.

The perilymphatic cavity is inserted into the lymphatic tract of all vertebrates,[2] and, being in connection with the subarachnoid space, it is easily seen how changes of any kind in the cerebro-spinal fluid can be communicated to the perilymph and thence to the organ of hearing. Hence, morbid processes in the subarachnoid space may be communicated to the organ of hearing, either by the peri- or endolymphatic tract, or by both ways at the same time. In this manner, a not unsound explanation may be given of numerous affections of the internal ear.

Hasse reiterates his views on the endo- and perilymph in an article in the *Archiv für Ohrenheilkunde*, Bd. xvii. Heft 3, S. 194, March, 1881.

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[1] See pp. 94–97.

[2] Hasse, op. cit., p. 815.

PHYSIOLOGY.

Cochlea.—The physiology of the perceptive part of the organ of hearing has been explained most satisfactorily by Helmholtz and Hensen, the latter having made a series of experiments upon the function of hearing in the crab and lobster, since upon the surface of these animals there are largely developed cilia, endowed with peculiar vibratile functions, and probably connected with the organ of hearing.

It is now generally supposed that the cochlea enables man to perceive musical notes, or notes and sounds with regular periodic vibrations, and that the membranous labyrinth is concerned in the perception of irregular vibrations, which are distinguished as noises. In the labyrinth, the distribution of the acoustic nerve may be traced to particularly firm and elevated spots at five different points, viz., in the two sacculi and three ampullæ. Imbedded in these elevated spots, and in connection with the nerve-fibres terminating there, are peculiar, stiff, elastic hairs or cilia, which are very brittle and pointed. "Such delicate, stiff hairs are apparently in a high degree susceptible of being moved by the motions of the fluid in which they are, and, in consequence of such movements, they produce a mechanical irritation of the nerve-fibres lying imbedded in the soft epithelium at their base."[1] Furthermore, there are found in close proximity to these acoustic cilia, calcareous bodies, the so-called otoliths, which, in the fish, bear an impress on their convex surface of the aforesaid prominence, containing the rich distribution of the acoustic nerve. In man, however, these otoliths only lie close to the wall of the membranous labyrinth. These crystalline bodies appear specially adapted to exert a mechanical influence over the nerve-filaments lying near them at each sudden movement of the water of the labyrinth, for "the delicate and light membrane in which the nervous branches are interwoven, in all probability follows instantly the motion of the labyrinth water, while the heavier crystalline bodies, the otoliths, are set in motion more slowly, and are longer in coming to rest. Hence, they partly drag and partly press upon the neighboring nerves."[2] Thus a powerful and enduring excitation of the vestibular branch of the acoustic nerve is effected by means of the peculiar structure of that part of the membranous labyrinth containing it.

While considering the physiology of the cochlea, the terminal filaments of the cochlear nerve in the ductus cochlearis must be called to mind.

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[1] Helmholtz, Die Lehre von den Tonempfindungen, p. 213.

[2] Helmholtz, op. cit., p. 214.

It will be remembered that in the nervous fringe lying on the lamina spiralis, there were certain arched supports of the delicate nerve-ends on their way to the hair-cells. These, the arches of Corti, were stated to be about 3000 in number. It is supposed by Helmholtz that each one of these arches is specially tuned so as to perceive a given note in the musical scale, just as in the piano-forte each wire is tuned to a note different from that of its fellows.

Although it is generally conceded now among physiologists that the arches of Corti have no sentient properties themselves, but are simply supports for the ciliated cells, which, being connected with the ultimate nerve-fibres, are the true sentient portions of the organ of Corti, nevertheless the arches may be considered as representatives, in a topographical sense, of the terminal nerve-filaments.

"If," says Helmholtz, "we leave out of consideration two hundred of the arches of Corti, too high to be used in the ordinary musical scale, we still have 2800 for the seven octaves of the ordinary musical instruments, *i. e.*, 400 for each octave and 33$\frac{1}{3}$ for each semitone; quite enough to explain the ability of perceiving fractional parts of a semitone, whenever such an ability exists. Skilled musicians, according to E. H. Weber, of Leipsic, can distinguish a difference between two notes, whose rates of vibrations are in the proportion of 1000 to 1001, equivalent to $\frac{1}{64}$th of a semitone, a quantity too small to correspond with the aforesaid interval between the individual arches of Corti. However, that does not militate against our hypothesis, for if a note is sounded, whose pitch lies between two neighboring arches of Corti, it will set both of them in consonant vibration, but that one whose fundamental note agrees most nearly to that of the note sounded will be set most violently in vibration. It will, in fine, depend only on the delicacy in the degree of excitability existing between two such nerve-fibres, and how small a difference in pitch in the interval between fibres we can distinguish. Thus it is we can explain the fact that when a note is continually rising in pitch, our perception of it changes gradually and not with jerking intervals, as it would if only one at a time of the terminal nerve-fibres were set in consonant vibration. . . . . The simultaneous perception of several notes of various pitches is due to the perceptive power of different nerve-fibres. Hence, the perception of clang-tint or timbre depends upon the fact that any note, besides setting in vibration that particular organ of Corti corresponding to its fundamental note, also excites perception in several different groups of nerve-fibres attuned to its partial tones."[1]

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[1] Helmholtz, op. cit., pp. 230, 231.

The theory of audition, as just described, has been further substantiated, Helmholtz claims, by the experiments of Hensen,[1] upon the organ of hearing in crustaceans, in which cilia endowed with acoustic power are situated on the external surface of the body. This investigator found that after he had destroyed the ear, or the saccules corresponding to that organ, in the mysis or opossum-shrimp, but retained the external acoustic hairs or cilia on the antennæ, the power of hearing was still present in the animals. By conveying musical notes through water in a box in which a mysis was so fastened as to permit of examining the external acoustic hairs of its tail, Hensen perceived that certain notes of a horn, the instrument used in the experiment, would set certain acoustic hairs strongly in motion, thus demonstrating most forcibly the theory that in the perception of musical notes certain vibratile cilia and nerve-fibres connected with them are intimately concerned, but, according to Prof. A. M. Mayer,[2] who has described a similar process in the so-called auditory apparatus of the culex mosquito, the process in both mysis and mosquito is only analogous to the process in the cochlea of vertebrates. In the organ of Corti there is in all probability a means of analyzing sound, whereas in the acoustic cilia of the crustacean and insect already named, there is supplied a means of conveyance of sound rather than an object to which sound is conveyed. Such physical facts were also alluded to by Dr. Christopher Johnson,[3] in 1855, who believed that whenever auditory organs are developed in insects, their seat is near the antennæ.

Although Helmholtz believes that he can utilize the experiments of Hensen, to prove his theory of audition, Hensen believes the theory of Helmholtz untenable.[4] He states that Corti's fibres cannot play the important *role* in the perception of tones ascribed to them by the theory of Helmholtz. Corti's fibres are a prominent and peculiar structure in the cochlea of mammals, and hence histologists have always regarded them as structures important to the physiologist. But these structures are not elastic enough, according to Hensen, to act as vibratile bodies. It is not known whether they are tense or not, nor is it known how such a tension could be maintained. If the fibres of Corti were elastic, it should be expected that when they are bent they would always reassume their previous shape, but this is not the case. Hensen further maintains that the stiffness, *i. e.*, elasticity of Corti's fibres, is entirely unproven and very improbable. They are, on the contrary, very probably extremely flexible. Then, further, Hensen maintains that Corti's fibres do not form a regular series corresponding to the musical scale, as he finds a decrease in the height of the arches of one-half, and in breadth one-quarter. This change in form, it is claimed, does not agree with the physiological postulate, viz.: that the vibrations must increase from 32 to 32,000 a second, since a corresponding morphological alteration is found only approximately. Even if it be asserted that on account of the different medium (water, not air), and the microscopic size, the circumstances are so changed that a conclusion applicable to rods vibrating in air cannot be applicable to these bodies, as Hensen has observed, in crustaceans, in lobsters, for example, the auditory apparatus of which is microscopic in size, and lies freely exposed and acting under water. In the lobster, however, the dimensions are graded in a striking manner, passing gradually through hundreds of fibres or cilia, from relatively colossal to quite small structures, the greater ones being many times in length, breadth, and thickness larger than the smaller ones. But a decrease in size, corresponding to that in Corti's fibres, is by no means found. Even if the scale range in the lobster is double that in man, which is not probable, still a corresponding difference in the fibres cannot be demonstrated. The slight decrease in size can find an explanation in other ways; but it does not suffice for the physiological hypothesis set forth by Helmholtz. The fibres of Corti require an extremely slight damping, as the endolymph alone acts as a powerful damper. If the damping is too strong, the separate parts would vibrate in consonance with too great a number of tones. Respecting the nature of the vibration of Corti's organ, Hensen holds that if the entire arch is supposed to be the vibrating body, it would be necessary to assume that the vibrations are longitudinal, for in order to produce an effect upon the terminal filaments of the nerve, in their natural position, the movements must necessarily be up and down. Again, Corti's organ is so constructed that it does not seem possible for a single arch to vibrate alone, but, when moving, one arch would drag neighboring fibres with it. The firm connection known to exist between the inner and outer arches alone makes a powerful damper, and interferes with a longitudinal vibration. It is more probable that the vibration of these arches is transverse than longitudinal. Hensen believes that through the hypothesis of Helmholtz we have the right to assume that organs important for the perception of music lie in the labyrinth, but no one can assume with certainty that they lie in the cochlea, for, as has been shown by Hasse, in birds there are no Corti's arches to be found. The latter fact alone, in Hensen's opinion, is sufficient to nullify the theory of Helmholtz concerning the function of the cochlea.

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[1] Physiological Institute of Kiel, Germany.

[2] Researches in Acoustics, No. 5, p. 9; American Journ. Sciences and Arts, vol. viii., 1874.

[3] Quarterly Journal of Microscopical Soc., vol. iii.

[4] Experimentelle Studien der Physiologie des Gehörorgans, von Schmiedekan und Hensen. Kiel, 1868.

To the question, "Are noises perceived in the cochlea, or is it correct to suppose the existence of another organ by which such sounds are heard?" the following conclusion is offered as an answer by Sigmund Exner.[1]

Physiological acoustic facts force us to the alternative, either that in the ear there is a special organ endowed with the faculty of perceiving noises as such, or that the nerves of the cochlea are endowed with such a peculiarity of function: The latter supposition is deserving of preference, for in obedience to it the nerves of Corti's organ receive an excitation not only when the vibrations of those parts of the membrana basilaris which underlie them have reached a certain length, but also at such a time as when the motion of the cochlear fibres becomes very rapid even by a slight impulse.

The sensation of a musical note occurs if only a few of the cochlear fibres are set in relatively slow consonance, but there occurs the sensation of an objective noise, whenever all the fibres of the membrana basilaris are hurried out of their position with relatively greater velocity.

Function of the Semicircular Canals.—The experiments of Flourens, in 1817, first drew attention to the probability that a lesion of the semicircular canals would produce peculiar disturbances in equilibrium of the body. His experiments were performed chiefly upon pigeons and rabbits, and consisted in wounding and irritating the semicircular canals and their contents. Subsequently his experiments were repeated by Harless, Czermak, Brown-Séquard, Vulpian, and Goltz. Without doubt many of their results, attributed to a lesion in the semicircular canals, were in reality attributable to injuries of the brain and other parts, incident to the experimental operations; a fact which, indeed, Flourens appears to have recognized in his own labors.

With the experiments of Böttcher, in 1872–73, there begins an era of more careful manipulation and protection of the brain and the vessels about the semicircular canals during the investigations. This endeavor to exclude results due to lesions of parts other than the semicircular canals has been paramount in the recent labors of Bloch, Cyon, Mach, Berthold, Breuer, Curschmann, Löwenberg, and Bornhardt; and to these men belongs the honor of having conducted the most brilliant physiological experiments of modern times.

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[1] Zur Lehre von den Gerhörsempfindungen. Pflüger's Archiv, xiii. S. 228, and Monatsschrift f. Ohrenheilkunde, No. 9, 1876.

Flourens noted that wounding the horizontal semicircular canals was followed by to-and-fro horizontal movements of the head, and that section of the vertical horizontal canals was followed by a vertical movement of the head upward and downward. He was led to conclude that he had found a new pair of nerves in the semicircular canals, "endowed with the singular faculty of influencing the direction of motion" (doué de la faculté singulière d'agir sur la direction des mouvements).[1] He also stated that destruction of the semicircular canals in no way affected the sense of hearing, unless it was to render it more sensitive. The experiments of Harless[2] and Czermak[3] were in the main corroborative of those of Flourens; though Harless concluded that he had observed a form of disturbance different from those of Flourens, yet dependent upon a lesion of the semicircular canals. Brown-Séquard[4] then endeavored to show that it was a coincident dragging and wounding of the acoustic nerve, in these experiments, which produced the peculiar alterations in coördination of movements; but Schiff[5] thereupon stated that wounding of the acoustic nerve, so long as the fifth pair was left intact, had no effect upon movements of the body. He also denied the existence of a nerve in the semicircular canals endowed with the peculiar power of coördinating muscular movements as was held by Flourens.

By wounding the semicircular canals, Vulpian[6] obtained results similar to those observed by Flourens; but he explained them as being due to disordered sensations of sound. This view, however, has not appeared tenable in the light of subsequent experiments by others; it is especially opposed by Böttcher.

Goltz,[7] after a series of experimental sections through the semicircular apparatus of the internal ear in birds and frogs, not only doubted whether the semicircular canals are organs of hearing, but advanced the theory that they constitute an arrangement which serves to maintain the equilibrium of the head and mediately of the entire body. In his opinion these canals have more control in regulating the carriage and movements of the head, than the senses of feeling and sight.

The investigations of Böttcher[8] and Bloch[9] were undertaken with a view of repeating Flourens's experiments; of discovering upon what the peculiar manifestations he had obtained depended; and of finding an explanation of them.

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[1] Recherches expérimentales, etc., p. 493, 2d edition, 1842.
[2] Wagner's Handwörterbuch d. Physiologie, vol. iv.
[3] Comptes rendus, 1860, and Jenaische Zeitschrift, 1867.
[4] Lectures on Nervous System, Philadelphia, 1860, p. 195.
[5] Lehrbuch d. Physiologie, 1858–59, p. 399.
[6] Leçons sur la Physiologie, p. 601.
[7] Pflüger's Archiv f. Physiologie, Bd. iii. pp. 172–98.
[8] Kritische Bemerkungen, Dorpat, 1872.
[9] Repetitions of Flourens's Experiments, Dorpat, 1872–73.

The preliminary labor of Bloch, was followed by a more extended series of experiments by Böttcher. The latter has shown that previous observers have not been fully aware of the injury done to the soft parts, surrounding the semicircular canals, especially to a certain portion first described in this connection by Schklarewsky, and named by him the cerebellar process. He thought that many of the phenomena obtained by previous observers were really due, not to lesions of the semicircular canals, but to an injury of the above-named portion as he supposed of the cerebellum, extending into the cavitas meso-otica.[1] Böttcher claims that this cerebellar process is nothing more nor less than the aquæductus vestibuli.

Böttcher's experiments are further characterized by great care in avoiding injury of all other parts, especially of blood-vessels, and also by a thorough and continued observation of each case operated on, until either recovery or death ensued. In the latter event the pathological anatomy has been fully studied, and its importance acknowledged.

Böttcher divides his experiments into three groups: 1. Those cases in which, partly by accident and partly intentionally, the artificial lesion was considerable; in these cases the results were similar to those obtained by Goltz. 2. Those cases in which notwithstanding great precaution the operation was incomplete, in so far as that after section of the semicircular apparatus on both sides, very different, but very distinct disturbances in motion occurred and alternated with one another. They were, however, entirely independent of one another. 3. This last group comprises those cases in which, after section of the semicircular canals on both sides of the head, only very insignificant disturbances in motion occurred, which completely vanished after they had persisted for a short time.

The conclusions drawn by Böttcher from his investigations are as follows:

1. The twisting of the head to one side and the accompanying resting it on the ground, so that the top of the head touches the ground and the beak points more or less backward, can be produced by cutting the canals on one side, if the operation is performed roughly, but if the canals are cut with great care and without simultaneous injury of other parts, the above phenomena will not appear.

He concludes, therefore, that the twisting of the head is not a symptom of section of the semicircular canals. Since, however, this peculiar rotation of the head does occur some time after the operation, it must be attributed to secondary changes in the contents of the skull. In such cases he has found either extravasations on the cerebellum or the medulla oblongata, or inflammation of the membranes of the brain.

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[1] A space described by Schklarewsky, as peculiar to birds, bounded by the semicircular canals, in direct connection with the cranial cavity, and containing an offshoot from the cerebellum. Göttinger Nachrichten, 1872, No. 15.

2. The direction of the rotatory movements and the movements of the body backward and forward about the transverse axis were shown to be dependent upon the canal cut, as was first discovered by Flourens; but they are independent of anatomical changes in the cavity of the skull. Nevertheless, they are not due to section of any two corresponding canals, *i. e.*, not to the destruction of their function. Böttcher does not say that the cutting of the canals is not the cause of the occurrence of these disturbed movements; in fact, he believes that it is the cause; but the disturbances which follow are evidently due not to the injury of the labyrinth purely, but to other changes almost inseparable from it. In proof of this it is stated: (*a*) that after section of the semicircular canals on both sides the disturbances in motion which have begun may entirely cease, and the animals experimented upon recover. If the vertigo and disturbed movements were due to the section of the canals, they should persist.

(*b*) The fact that the disturbances in motion are observed always in the extremities on the side operated on is urged as further proof that not the section of the canal alone is the cause of the altered muscular movements.

(*c*) Again, the motor disturbances are observed in some cases in both walking and flying, in other instances only in walking or in flying. This is urged by Böttcher as a striking proof that vertigo cannot possibly cause the disturbances in motion; for if it did both acts would be equally interfered with. The lesion, therefore, is supposed by him to be purely a local one, affecting only either the legs or the wings.

(*d*) Finally, it is worthy of note that the character of the disturbance in motion is not dependent upon which of the semicircular canals is cut, but upon the point where the section is made.

The pendulum movements of the head are only a passing symptom, occurring with greatest intensity immediately after the operation, but gradually diminishing and finally ceasing. These pendulum movements persist in some cases, in which at no time the head of the animal is held in an abnormal position. In some instances, notwithstanding that the canals are cut on both sides, these peculiar movements do not occur. If rotation of the head occur, then the pendulum movements cease.

The twisting of the head and the tumbling usually connected with it, occurring after section of the semicircular canals, are attributable either to a cerebral lesion produced at the time of the operation, or to pathological processes developed later in the deeper parts of the central nervous system.

The *mouvements de manège*, *i. e.*, going round and round in circles, like a horse in the circus-ring, and the tendency to fall forward or backward, are involuntary movements having their foundation in changes produced in the crura of the cerebellum by the section of the semicircular canals, as already pointed out by Flourens.

The pendulum movements of the head, to and fro in either a horizontal or vertical plane, are *connected* with the section of the semicircular canals, but Böttcher is not disposed to admit that their occurrence is dependent on such a lesion. His experiments, as he believes, show these last-named movements to be dependent on a sympathetic affection of the brain. Furthermore, the fact that pendulum movements are as a rule followed in a few days by twisting of the head, would seem to indicate that there is a common cause for both.

Cyon's[1] experiments induced him to come to conclusions similar to those of Vulpian, viz.: that the function of the semicircular canals is to inform the animal, by means of a series of unconscious acoustic perceptions, of the correct position of its head in space, and for this purpose each semicircular canal has an exactly determined relation to a direction in space. He also attributed the disturbances in motion which occur after section of the semicircular canals to direct results of the artificial injury, to involuntary movements resulting from the abnormal acoustic perceptions produced by the same means, and to consecutive manifestations produced by inflammation of the cerebellum, which sets in a few days after operation.

To illustrate the physical phenomena of the semicircular canals, Dr. Breuer[2] has used a system of three tubular rings filled with fluid, placed at right angles to one another, thus gaining a fair representation of the semicircular apparatus of the labyrinth. If a rotary motion be given to such a system, currents of the contained fluid will occur in a direction opposite to that of the applied motion. Such movements in the lymph of the labyrinth are supposed to occur in every movement of the head, the measure of the current in each semicircular canal depending upon the plane in which the head is turned, and also upon the amount of rotation. A perception of the movements of the fluid of the labyrinth may furnish exact information respecting every turning of the head. The acoustic cilia are brought forward as the possible perceptive apparatus of this movement, for they are situated at a broad, smooth spot in the canal and project at right angles into its calibre. Thus, from their position, they would be especially sensitive to the variations of the currents in the endolymph, and it is known that they are connected with nerves, the terminations of which they represent.

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[1] Pflüger's Archiv, Dec. 1873, vol. viii. p. 306.

[2] Wiener Med. Jahrbücher, 1874, Heft I.

In order to harmonize both of these facts with Goltz's theory, Breuer assumes that every current of the endolymph is perceived by the nerves of the ampullæ, that it produces an idea of the rotation of the head in the plane of the semicircular canal most implicated, in a direction opposite to the current, and that the perceptions of the six ampullæ of both labyrinths unite in forming a joint conception.

E. Mach[1] has seemed to add corroboration to the theories of Goltz and Breuer by a series of novel experiments upon man, which were published a short time before the results of Breuer's labors.

Mach suspended a chair in which a man could sit with ease, in a framework, so that the chair could be revolved about a horizontal axis and fixed at any inclination. In addition, the entire framework with the chair could be revolved about a vertical axis. In many of the experiments the chair was covered by a paper box, which, following all the motions of the chair, prevented the person sitting in it from observing with his eye the motions of the apparatus in which he was seated.

The principal results of the experiments with this apparatus were the following:

A revolution about the peculiar vertical axis of the body is perceived by the person experimented upon only so long as it is accelerated.

A continued and constant revolution is not perceived.

Retardation of the revolution is perceived as a revolution in the opposite direction.

It is apparent that these facts agree with the theories of Breuer. The sensation of revolution in the opposite direction is converted into the sensation of motion in the true direction, in two seconds, by a renewed acceleration of the original motion. This sensation, therefore, must continue a few seconds longer than the cessation of the retardation; for otherwise, the new acceleration should produce immediately a sensation of revolution in the original direction. If we accept Breuer's hypothesis, we must suppose that by the law of inertia the currents produced in the semicircular canal continue some seconds after the force producing them has ceased.

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[1] Wiener Sitzungsberichte, Nov. 6, 1873.

If during the revolution about the vertical axis the head is inclined forward and then suddenly elevated at the moment the revolution ceases, in those cases where the revolution has occurred from the left, forward and towards the right, an impression will be gained that a revolution is occurring from the right, upward and towards the left, and the person thus experimented upon will fear that he is about to fall towards the left. This fact is also in harmony with the hypothesis of Breuer, and proves most strikingly that the position of the head is a measure of the sensations of revolution, and that the organ of these sensations must be found in the head. These two fundamental facts have already been observed by Purkinje. Furthermore, Mach has established, by the aid of his apparatus, the fact that we have, either with the body at rest or revolved with a constant velocity, a distinct consciousness of the direction of the resultant accelerating force, without the assistance of the eyes. A man sitting in Mach's chair was able to give, by means of an indicator projecting from the case, a tolerably correct statement as to the vertical direction in any of the variously inclined positions of the chair.

When the case containing the chair was revolved about a vertical axis situate at some distance from the chair, and when the face of the one experimented with was turned towards this axis, the axis then given by him as the vertical one was in reality one inclined diagonally downwards from the axis corresponding to the resultant of the centrifugal force produced by the revolution with constant velocity, and the weight of the body revolved.

Certain facts of a similar nature, perceived prior to this, induced Breuer to add to his hypothesis already described, the supposition that we should consider the macula acustica with the otoliths as possibly an organ for the perception of the position of the head at rest, in respect to the direction of the resultant accelerating forces and the rectilinear motions. In this portion of the acoustic apparatus he perceives the fulfilment of the necessary conditions and assumes that the otoliths are specifically heavier than the endolymph, and that they consequently have a tendency to sink in it in the direction of the resultant accelerating force. According to the direction of this force in the head, the otoliths would drag, in various ways, upon the hairs with which they are connected, and thus produce a varied excitation of the terminal nervous apparatus.

In addition to this, the specifically heavier otoliths would have, at the beginning of a rectilinear motion, a tendency to remain behind the endolymph, and at the cessation of the same they would go in advance of it, and therefore they would, by mechanical action upon the cilia, produce a perceptive sensation.[1]

Berthold's[2] experiments were performed with great care to avoid any implication of the central organ. He confirmed the above-mentioned statements of Schklarewsky and Böttcher, respecting the danger of wounding the aquæductus vestibuli; in order to avoid hemorrhage or any undue lesion he used silk thread for cutting through the canals. *Manège* movements, consequent upon section of the semicircular canals, were not observed by Berthold, but vomiting was found to occur in cases where it could not be attributed to injury of the brain. He also observed that injury of the above-named "process of the cerebellum," or aquæductus vestibuli, alone produced symptoms partly resembling those resulting from injury of the semicircular canals. His final conclusions are in favor of regarding the function of the semicircular canals as assisting in the coördination of motion by means of reflex action. They perform their function in company with two other senses, viz., with that of sight and with that of touch.

The experiments of Flourens and Goltz, on pigeons, have been repeated by Curschmann,[3] who has observed three very important cautions in his investigation, viz.: 1. The least possible destruction of tissue about the semicircular canals; 2. The avoidance of excessive hemorrhage, especially from the venous sinus near the canals; and, 3. The infliction of the least possible injury to the bony canals, since, from their intimate relation to the cavity of the cranium, they cannot be destroyed without a previous opening of this cavity, which is followed by an immediate or secondary injury of the cerebellum.

The conclusions of Curschmann are that: 1. Injuries of the semicircular canals are positively followed by disturbances in the equilibrium of the body; 2. The phenomena are proportional to the lesions; 3. The derangements are constantly observed in connection with muscular movements; 4. The canal operated on, as well as unilateral or ambilateral destruction of the semicircular canals, determines the character of the resultant phenomena; 5. The phenomena are the more intense and defined, the more energetically the animal moves about; 6. The phenomena of deranged coördination in muscular movements are expressed in the head, trunk, and limbs of the animal operated on; 7. The supposition that the derangements of motion of the trunk are due to a defective carriage of the head is not tenable; 8. After total removal of all three membranous canals on both sides of the head, the pigeons do not appear entirely bereft of the power to direct their movements; 9. Simple section of a single canal, if the structure is not secondarily diseased, is followed in four or five days by a diminution, if not a total cessation, of the resulting phenomena, even without a *restitutio ad integrum* on the part of the incised canal; 10. The almost constant increase of, and frequent changes in, the original symptoms, appearing after extensive injury to the canals, are referable to subsequent disease of the remnants of the injured canals, or to secondary alterations of the canals which were left intact; 11. The semicircular canals are not to be considered as an organ of the sense of equilibrium; 12. The phenomena are the result of a cessation of function, not the result of an irritation, certainly not of a specific irritation of the acoustic nerve; 13. Since the hearing is not materially altered by a removal of the semicircular canals, it cannot be concluded that they are not connected with this sense.

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[1] See abstract by Prof. Fick, Archiv f. Ohrenhheilkunde, vol. ii. N. F., p. 306.

[2] Archiv f. Ohrenheilkunde, Band ix., 1874.

[3] Deutsche Klinik, No. 3, 1874, Archiv f. Ohrenheilkunde, vol. ii. N. F. p. 307 abstract by Prof. Lucæ.

Löwenberg's experiments[1] have led him to the following conclusions: 1. The derangements in motion, which manifest themselves after the semicircular canals are cut through, depend upon such section only, and not upon the accompanying injury to the brain. 2. Vomiting, which was noted by Czermak in his experiments, depends upon the attendant injury to the cerebellum. 3. The disturbances in motion are due to irritation of the semicircular canals, not to paralysis of them. 4. The irritation produces, reflectively, spasmodic paralysis, without participation of consciousness; fresh irritations of the canals are induced only by calling forth voluntary movements. 5. The conveyance of this reflex excitation to the motor nerves occurs in the thalamus. 6. Section of the auditory nerve does not produce these derangements of motion.

Bornhardt[2] is forced to conclude that the phenomena of deranged movements succeeding section of the canals are due to unavoidable injuries of other parts. He rejects the theories of Breuer and Mach, and is of the opinion that "the semicircular canals serve, by transmission of the *vibrations resulting from muscular contraction*, to intensify the muscular sensation during action of the muscles of the head. The following experiments Bornhardt considers as confirmatory of this conclusion: The horizontal semicircular canal of a rabbit being exposed without injuring its osseous covering, and the back of a knife being rubbed backward and forward upon it, by which means it is merely agitated, the same movements of the head and eyes occur, which are characteristic of division of the membranous canal. The direction of the muscles attached to the head is parallel to the direction of the semicircular canals, which fact seems to favor the above conclusion. Movements similar to those resulting from division of the canals have been induced by an experiment which leaves the brain and osseous canals intact. The vertical and horizontal canals in pigeons were exposed to a continuous stream of ether by means of an atomizer; they were also touched with a red-hot needle. In both cases the same symptoms appeared as in division of the canals; the same result was also obtained by touching the canals with a vibrating tuning-fork.

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[1] Archives of Ophthalmology and Otology, vol. iii. part ii. pp. 26–44.

[2] Med. Centralblatt, May, 1875, and Blake's Report on Progress of Otology, American Otological Society, 1875.

Baginsky,[1] of Berlin, after a series of experiments on pigeons, has come to the conclusion that if the brain is not wounded in experimenting on the semicircular canals, disturbances in equilibrium will not manifest themselves. As proof of this he instances those cases of disease of the ear in which necrotic exfoliation or degeneration of the entire labyrinth occurs, and yet there are no phenomena of altered equilibrium unless the brain is affected at the same time and by the same process.

Vulpian's[2] recent experiments, made by instillations of irritants into the external auditory canal, lead him to suppose that the disturbances in gait and equilibrium, are due to the rapid imbibition of the irritant fluid, through the fenestræ, and consequent irritation of the nervous apparatus in the vestibule and semicircular canals.

CHAPTER II.

SCHEME OF RELATIONSHIP BETWEEN THE MIDDLE AND INTERNAL EAR.

Schematic Description of the Middle Ear, of the Internal Ear, and of the relation they bear to each other.—In order to understand the general features of the middle ear and of the internal ear, and the general relations they sustain to each other, let there be imagined, first, a broad and shallow barrel, closed at each end and divided in the middle by a partition.

If this barrel be laid upon its side with one end towards the reader, it will give a fair representation of the *middle* ear, in the near half, and of the *internal* ear in the far half. The head of the near half of this barrel will represent the membrana tympani or drum-head, while the partition in the centre of the barrel represents the inner bony wall of the tympanic cavity. In this partition let two openings be made, one oval-shaped, the other, round. The former must be above and in front of the latter. The former represents the *foramen ovale* or the oval window, and the second, the *foramen rotundum* or the round window.

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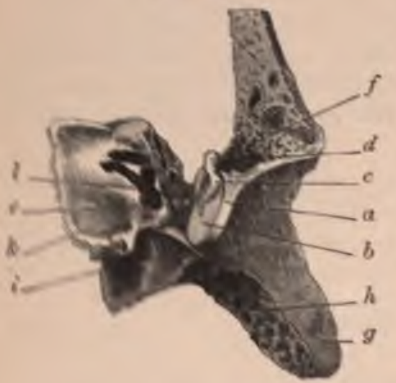
[1] Ueber Schwindelerscheinungen nach Ohrverletzungen. Monatsbericht d. Berliner Akad. d. Wissensch., Jan. 13, 1884.

[2] Academie des Sciences, Jan. 8, 1883.

From the membranous head of the near half of the barrel to the partition in the centre, is stretched a bony bridge composed of three pieces. This of course is the chain of ossicles, containing the malleus or mallet, the incus or anvil, and the stapes or stirrup, and stretching from the membrana tympani to the inner wall of the tympanic cavity.

The handle of the outermost of the three ossicles, the manubrium of the mallet, is inserted into the fibrous or middle layer of the drum-head; the innermost, the stirrup, by means of its foot-plate, fits into the oval window in the inner wall of the tympanic cavity, and the middle bonelet, the anvil, is held in position between the other two. They are furthermore held together and fastened to the roof and wall of the tympanic cavity, by means of ligaments.

Fig. 48.



Complete Auditory Apparatus of Man. (Natural size.) Left side.—*a*. Annulus tympanicus. *b*. Membrana tympani. *c*. Malleus. *d*. Head of malleus. *e*. Stapes in oval window on the left; attached to incus on the right. *f*. Mastoid cells laid open. *g*. Mastoid process. *h*. Lower mastoid cells. *i*. Jugular fossa. *k*. Position of cochlea, removed. *l*. Vestibule, and semicircular canals partly laid open.

This bridge of ossicles may be said to have two guys which steady it and give it proper tension, one of which is fastened to the mallet and the other to the stirrup. The former will at once be recognized as the tensor tympani and the latter as the stapedius muscle.

In the outer half of the imaginary barrel are two bung-holes, one in front, the other on the back. The front bung-hole represents the tympanic opening of the Eustachian tube, by means of which the middle ear, or drum, is ventilated, and the atmospheric pressure on each side of the drum-head equalized. The back bung-hole is the communication between the mastoid cells and the cavity of the tympanum.

The mastoid portion may be likened to an ivory box filled with sponge, the latter representing the series of bony cells, which communicate with one another and at last by means of the mastoid antrum with the cavity of the middle ear.

In this simple manner, the middle ear, with its ossicles and more important appendages, may be sketched.

The functions of this cavity are dependent on aerial life, and equal pressure of air on each side of the drum-head.

This air-containing cavity is separated from the internal ear, or labyrinth, a *water-containing* cavity, by means of a bony partition, viz., the inner wall of the middle ear already described, in which is the oval window, into which the foot-plate of the stirrup fits. Hence, these two important cavities have one wall in common through which, by means of the foot-plate of the stirrup, the movements of the chain of little bones are communicated to the fluid of the internal ear and to the thread-like ends of the nerve of hearing suspended in it.

In order to understand the general features of the internal ear, let us still retain the simile of the barrel. In this instance the inner half of the barrel must be regarded as made entirely of bone, as filled with water, and communicating at *no point* with the atmosphere, but in direct communication with the arachnoid space by means of the aqueducts of the vestibule and cochlea.

Since the walls of the internal ear are made of bone, there can be no giving on their part to the pressure of the fluid of the labyrinth produced by the movements of the stapes. In order that these movements may go on, there is found at the extremity of one of the passages of the internal ear, viz., the cochlea, the round window, over which is stretched a membrane which yields slightly to the pressure brought about in the labyrinth by the movements of the stapes.

On the front of this inner cavity representing the *internal ear*, is a spiral tube, with two and a half turns. Being wound around like a snail-shell, it long ago received the name of *cochlea.*

On the back of this inner cavity are found five openings communicating with three semicircular tubes. We would naturally look for six openings into the ends of three semicircular tubes, but only five are found in this instance, as two ends of two of the semicircular tubes, viz., the superior and posterior semicircular canals, join together and have a common opening into the internal ear or labyrinth at that part of it called the *vestibule.*

On the far-head of this inner barrel-half, we find the nerve of hearing pushing its way into the labyrinth, through a *sieve-like spot*. After forcing its way into the cavity of the internal ear through this sieve-like spot in the inner bony wall of the internal ear, at the fundus of the internal auditory canal, the auditory nerve divides into two main branches, one of which, the cochlear branch, is distributed to the cochlea, and the other, the vestibular branch, is given to the sacculi and to the ampullæ of the semicircular canals.

PART II.

DISEASES AND TREATMENT.

SECTION I.

EXAMINATION OF PATIENTS.

CHAPTER I.

INSTRUMENTS AND METHODS OF THEIR EMPLOYMENT.

THE light employed in examining the ear is usually reflected into the auditory canal by means of mirrors, to be described later. But the ear may be examined by direct rays of light in such a way as to give considerable aid in some instances. If daylight is to be reflected into the ear, the light coming from the north will be found to be the most efficient. If, however, examination by direct rays of sunlight is desired, the ear must be so situated that the sun's rays may fall directly upon it. If artificial light is used, that of an Argand gas-burner will be found the brightest. In the examination of patients seated beside a table, the height of the flame, above the floor, should be at least 4 feet 3 inches, or from 6 to 9 inches above the patient's vertex. The flame of a petroleum-burning student-lamp is also very good, but if neither of these can be commanded, a candle will render good service, especially at the bedside, for it is much easier to move the light in examining a patient in bed than it is to adjust the head of the sufferer.

Examination of the Ear by means of Polarized Light.—This mode of examining the ear has been attempted by Drs. Hagen and Stimmel,[1] and they were able thus to effect the entire disappearance of the posterior-superior quadrant of the drum-head, and a consequent revelation of the long process of the incus and portions of the stirrup. Other portions of the membrana tympani appeared much thinner, and it was possible to determine the presence of adhesions and pseudo-ligaments in the tympanic cavity. By using this mode of examination, all opacities of the membrana tympani, such as calcareous spots, ecchymoses, and

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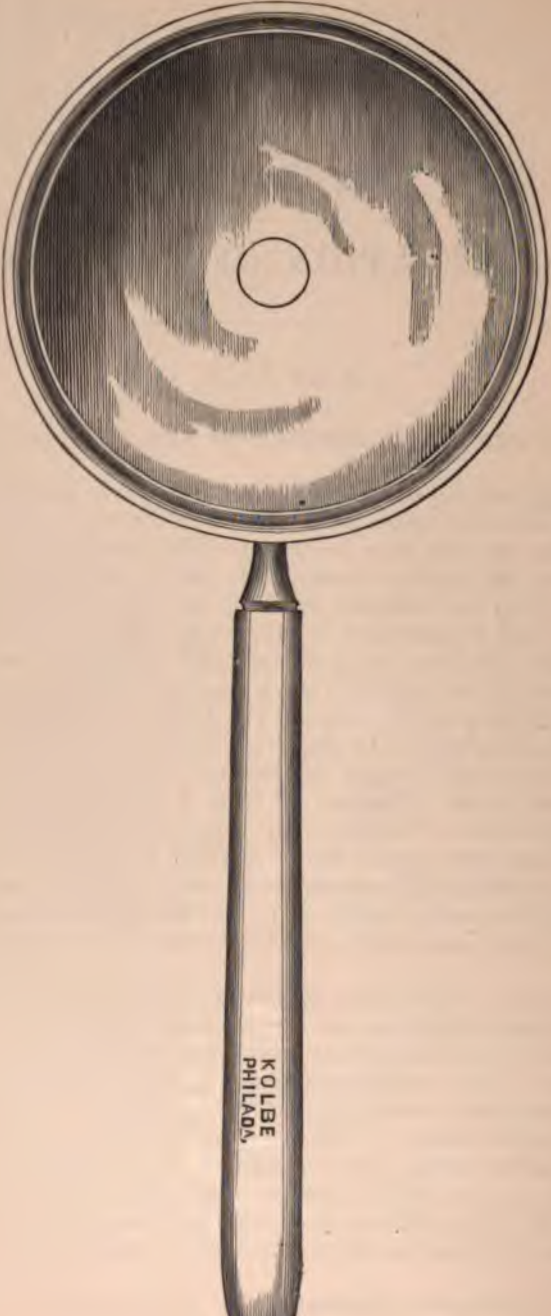
[1] See Report on Progress of Otology, by C. J. Blake, 1875.

Fig. 49.



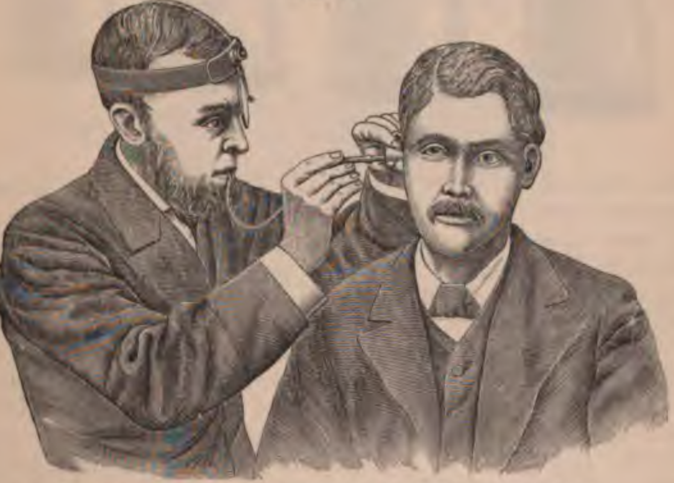
EAR-MIRROR.

the like, appear more distinctly defined, and the bloodvessels of the manubrial plexus were more clearly visible. Transparent spots seemed to disappear entirely. From what has been done already with this mode of illumination of the ear, it would seem that it could be rendered of the greatest aid in diagnosis, if its application be not too complicated.

Instruments for Examining the Ear.—The instruments used in examining the ear should be as simple as possible. The first demand is for a concave mirror with a focal distance of from four to six inches, according to the eye of the examiner. That form known as von Troeltsch's ear-mirror is most widely used, and is the best. (Fig 49.)

The Forehead Ear-mirror.—Equally as important as the hand ear-mirror is the forehead ear-mirror. It consists in the attachment of the same kind of a mirror as the former firmly to a forehead band of inelastic silk. There are many forms of attachment, but a ball-and-socket joint, which can be tightened or loosened as required, in which the ball of the joint is close to the periphery of the mirror, and in which the joint lies in the centre of the band, is the best, because, with the mirror thus brought so near the point of fixation, the greatest firmness is obtained. It is not necessary—in fact, it is best not—to endeavor to look through the hole in the centre of the mirror when on the forehead, but to look under it or to one side of it. In every

Fig. 50.

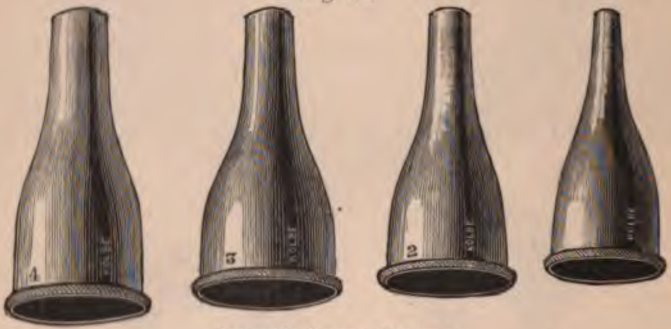


ILLUMINATION OF EAR BY MEANS OF THE FOREHEAD-MIRROR.

instance the mirror must first be adjusted with the hand, so as to throw the light to the best advantage into the speculum and canal. Then the operator can keep up the illumination of the ear by holding the mirror in the desired position, by his head, while his two hands remain free. The manner of its use can be seen by consulting Fig. 50.

Otoscopes, or Aural Specula.—The next want will be a nest of specula or ear-funnels. There are numerous forms found in the instrument-makers' shops, under the names of Kramer, Toynbee Wilde, Gruber, Politzer, and others. While all are good, preference should be given to Ignaz Gruber's specula, because a transverse section of their calibre at right angles to the long axis, most closely resembles a similar section of the auditory canal, *i. e.*, it is slightly ovoid in shape. The great object in using a speculum or aural funnel, is simply to hold the tragus away from the meatus, and to push away the stiff hairs about the opening of the external auditory canal. In some cases, moderate dilatation of the cartilaginous canal may be effected, but usually, all endeavors at dilatation of the external auditory meatus are worse than useless—*they are painful and injurious.*

Fig. 51.

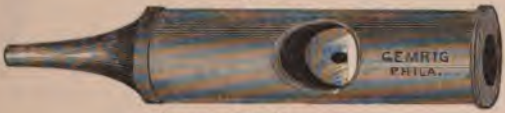


Gruber's Aural Specula.

Dr. E. D. Spear, of Boston, has devised a form of aural speculum to be used during operations. It is retained by the elasticity of the cartilaginous meatus. The speculum may be said to be 13 mm. long, 7 mm. wide at its inner end, and 10 cm. wide at the mouth. A section of its calibre is oval in shape, like that of the auditory canal. Its chief peculiarity and advantage consists in the fact that the anterior wall of the speculum is continued outward 18 mm. beyond the mouth, its outer edge, or lip, being about 18 mm. wide. This broad lip is intended to rest against the tragus, holding the latter away. The pressure of the elastic tragus against it aids in retaining the instrument in the meatus, a great consideration in operating on the ear.

All forms of specula or ear-funnels are made of metal or of hard rubber. Both kinds possess peculiar advantages as well as disadvantages. The first are less brittle than rubber, but they are colder in winter-time, and sometimes are objected to by the patient. On the other hand, the hard-rubber ear-funnels, while being more agreeable in feeling to the patient, are extremely brittle. In some instances, ear-funnels have been made of glass. This kind would be as little likely as any to be affected by the various caustics sometimes used in the treatment of aural diseases. But when such substances are applied carefully to the ear, no speculum will suffer, for the latter need not be touched by the medicinal substance. In any event, the metallic specula will be more easily attacked by acids, nitrate of silver, and the like, than the hard-rubber variety. In no case will it be necessary to oil the funnel before it is inserted into the meatus, for if it require greasing to make its way into the canal, then the instrument is either too large for the ear, or the auditory canal is too swollen to permit an examination by means of the ear-funnel.

Fig. 52.

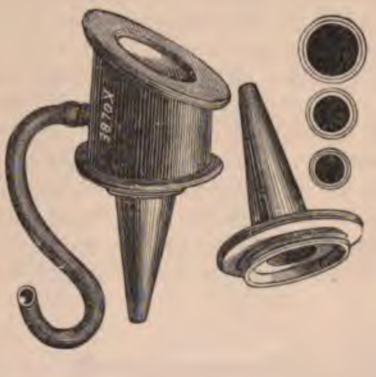


BONNAFONT'S OTOSCOPE.

If magnifying is desired, it can be neatly and cheaply obtained by the employment of Bonnafont's otoscope. The specula are adjustable, thus permitting the ready use of various sizes; these and the case are made of hard rubber. There is a magnifying eye-piece, and a perforated mirror for reflecting light into the auditory canal.

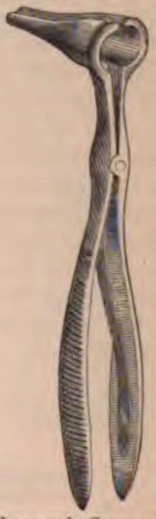
Siegle's Pneumatic Otoscope.—Dr. Siegle, of Stuttgart, some time ago, invented a most valuable instrument, which is known in Germany as Siegle's pneumatic ear-funnel. It consists in a hard rubber, round speculum, like Politzer's, to which is attached an air-tight chamber 3 cm. in diameter. The upper or outer wall of this chamber is glazed, and forms an angle of 40° with the plane of the inner wall. On the longer side of the chamber there is an opening with a perforated knob, to which is attached a piece of rubber tubing about a foot in length, ending in a mouth-piece for the surgeon. This chamber is made to screw off and on ear-funnels of different diameters. When all the parts are fully adjusted, the surgeon has an air-tight speculum with a glass end, through which he can examine the movements the drum-head makes during condensation and rarefaction of the air, brought about by his own mouth through the rubber tubing at the side of the instrument. This is really the only means the surgeon has of fully determining the mobility of the drum-head, though both Valsalva's and Politzer's methods of inflation, if carried out while the surgeon's eye is fixed on the drum-head, will give him some idea of the extent the membrane can move. But when the Eustachian tube is impervious, Siegle's instrument is the only means of determining the mobility of the parts or of the whole of the membrana tympani. Dr. Gorham Bacon, of New York, has improved this instrument by adapting to the air-chamber, Gruber's specula in place of round ones.[1]

Fig. 53.



SIEGLE'S PNEUMATIC OTOSCOPE.

Fig. 54.



KRAMER'S SPECULUM.

Kramer's Ear-speculum.—There is sold in the shops an instrument under the name of Kramer's ear-speculum. Its inventor, Dr. Kramer, of Berlin, designed it for use only in the direct rays of sunlight. This, of course, renders it an instrument of very limited usefulness respecting the ear. As it is a bivalvular instrument, and designed, therefore, for dilatation, it will slip from the meatus as soon as the handles of the instrument are brought together, or else great pain will be caused by its use. It is an admirable aid, however, in anterior rhinoscopy.

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[1] New York Medical Journal, Dec. 1, 1883.

Blake's Operating Otoscope.—Dr. Clarence J. Blake's operating otoscope is intended to overcome the disadvantages of the usual monocular examination of the ear. "It consists of a hard-rubber speculum (Politzer's) of the largest size, fitted with a metallic rim, to which is attached a revolving prism and an arm, bearing at its outer end a lens of about an inch focus; this arm is movable, but sufficiently firm to remain fixed at any angle at which it is placed. The prism is just within the focal distance of the lens, and its incident face is armed with a small metal shield, having an opening in the centre corresponding in its short diameter to the diameter of the pencil of light falling upon it from the lens. The advantage of the prism over a mirror or other reflecting surface is, that we have almost total reflection, and but little of the light concentrated upon the prism by the lens is lost.

"In operating, an assistant is required to draw the auricle upward and backward, and keep the speculum in position, with the funnel of light upon the opening in the shield of the prism. It is not claimed for the instrument that it at all supersedes the head-mirror of von Troeltsch, but it is certainly of great advantage in the more complicated operations, when a steady and uniform illumination is indispensable. The instrument, as a whole, weighs only about one hundred and twenty grains, and can be made much lighter; so that when once firmly inserted in the meatus, it remains in position, and there is no necessity for holding it nor fear of its slipping out of place during the operation."[1]

Dr. E. De Rossi,[2] Professor in the University of Rome, claims to have invented a binocular otoscope. It is simple and inexpensive, differing very slightly from the original form of Helmholtz's ophthalmoscope. It is so arranged on a forehead-band as to allow the use of both hands, but the distance of the eye from the membrana tympani, thirty centimetres, necessary to obtain a binocular view, renders the instrument of no very great practical utility.

Voltolini[3] has devised a pneumatic aural speculum, which is a compound of Siegle's pneumatic speculum and Brunton's speculum. With this he proposes to investigate the middle ear, after cutting away the posterior segment of the membrana tympani and turning it forward over the hammer. He thus obtains a more perfect view of the fenestræ of the labyrinth and of the stapes. He also proposes to operate with this speculum *in sitû*, by introducing a knife through a slit in the funnel-

[1] Roosa's Treatise, p. 87, 1873.

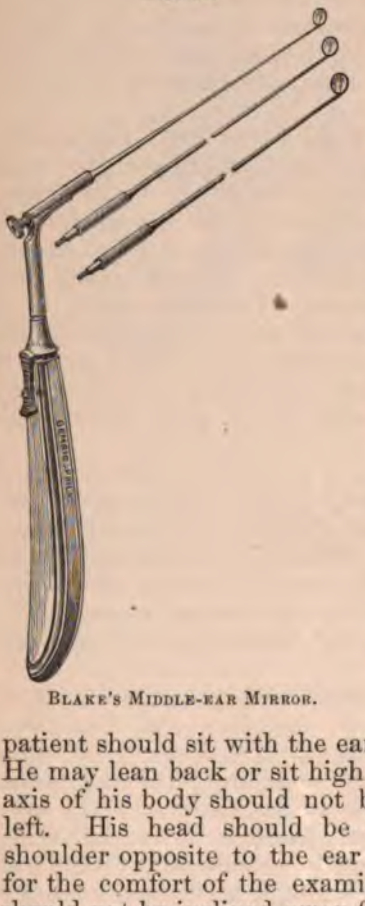
[2] Ein einfaches binoculäres Otoscop. M. . O No. 7, 1872.

[3] M. f. O., No. 2, 1873.

portion of the speculum. He reports one case of tenotomy of the tensor tympani performed successfully by its aid. The instrument is not all the inventor claims it to be, and therefore it cannot be considered a valuable addition to the diagnostic or surgical means of otology.

The middle-ear mirror of Blake[1] is the modification of the laryngoscope and rhinoscope, applied to the exploration of the tympanum with reflected light. The mirrors are of three sizes, as represented in the wood-cut, and are of polished metal. The mirrors are made so as to be flexible at the junction with the shaft, and are thus adjustable at any angle best suited for examining the walls and the roof of the tympanic cavity. By placing the shaft in a tenotome handle of Weber-Liel, the mirror can be rotated as desired, by moving the thumb-piece on the ivory handle.

Fig. 55.



Blake's Middle-ear Mirror.

Under thorough illumination of the auditory canal, these mirrors can be carried into the tympanic cavity if the membrana tympani be destroyed, and by careful manipulation the condition of the cavity may be studied. They are specially adapted to the search for, and examination of small polypoid growths on the roof of the cavity.

Position of Patient's Body and Head.—As by far the most usual way of examining the ear is by reflected light, I shall suppose, in what follows, that reference is made entirely to that mode. The patient should sit with the ear turned from the source of light. He may lean back or sit high and straight in the chair, but the axis of his body should not be inclined either to the right or left. His head should be inclined somewhat towards the shoulder opposite to the ear to be examined. It is important for the comfort of the examiner that the body of the patient should not be inclined away from him, for if it be, then a great strain must come on the back of the surgeon in his endeavor to reach after the ear.

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[1] Transactions American Otol. Soc., 1872.

Position of Surgeon.—The surgeon standing beside the patient, in front of the ear to be looked into, should grasp the auricle at its upper and posterior margin, gently between the index and middle finger of his left hand, and pull the auricle a little upward and backward. This is always to be done by the left hand, no matter which ear is examined. This leaves the right hand free to hold the mirror. The patient should be placed, and the surgeon should stand so that the light may fall on the mirror towards the surgeon's right side, or directly from in front—never from the left in the above position of patient and examiner. These rules of position of light, patient, and physician are especially important when artificial and reflected light is used.

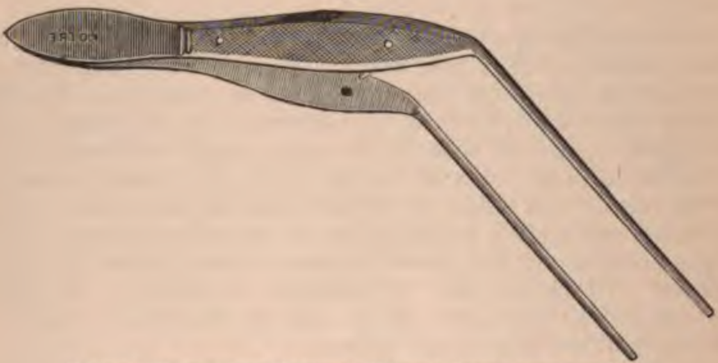
Insertion of Ear-speculum.—With the auricle grasped as directed above, between index and middle finger of the left hand, the speculum or ear-funnel may be gently inserted in a direction slightly downward, inward, and forward, or in general terms towards the patient's nose, by the other hand, and then grasped by the thumb and index of the left hand. Or it may be inserted by the thumb and index of the left hand at the same moment the index and middle fingers grasp the superior posterior margin of the auricle. In the latter instance a very gentle and slight rotation will be all that is sufficient to place the ear-funnel properly. The speculum being now in the meatus, light is to be reflected into it from the mirror.

The first point to be decided upon, in making an examination of the ear, is whether the auditory canal is entirely free from obstruction or not. If it is, then the eye of the observer should, after ascertaining the state of the wall of the canal, seek the membrana tympani. The chief obstacle in such a search is usually the misdirection of the axis of the funnel. This, instead of being made to correspond with the axis of the auditory canal, is directed most usually, by the unskilled, so as to fall on the sides of the canal or only partially on the drum-head. Hence it is not at all uncommon to hear a diagnosis made for the membrana tympani, which is based entirely on a view of the condition of the skin lining the auditory canal.

What should be seen at the fundus of the canal is described on p. 47, yet it will be a long time before the eye can accommodate itself to the conditions of illumination in the external ear, so as to interpret fully what it sees. The experienced eye is able to resolve into depressions, elevations, curves, etc., that which is projected entirely in the same plane by the beginner.

Removal of Obstacles to a View of the Membrana Tympani.—It requires but a small object, a few stiff hairs, or a flake of cerumen or of epithelium, to obstruct the view of the drum-head. All such obstacles are most easily removed by a few syringefuls of warm water; this, however, will render the drum-head a little macerated, and hence deprive it of whatever lustre it may have had. This must be borne in mind in looking at the drum-head after warm water has been syringed upon it. Therefore, when it is especially desirable that the amount of natural lustre in a given case should be estimated, an obstructive substance might better be gently and most carefully lifted or wiped out of the canal. The former is most readily accomplished by the delicate forceps shown in Fig. 56, while the canal is thoroughly illuminated by the forehead-mirror (Fig. 50, p. 161). If the obstruction to vision can be wiped or swabbed out, the cotton-holder, with its little wad of cotton at the roughened end, will enable one to do this.

Fig. 56.



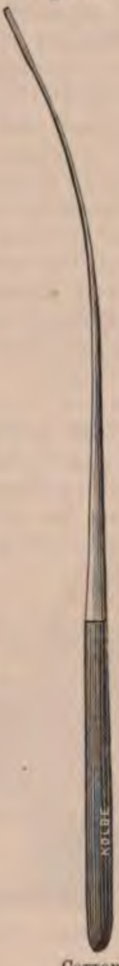
DELICATE FORCEPS FOR REMOVING FOREIGN BODIES FROM THE EAR.

The Cotton-holder.—This is a most useful instrument, both for cleansing the ear and conveying medications to diseased surfaces in the organ. The shaft is made flexible for an inch or two, as indicated in the wood-cut, and roughened at the tip. At the latter point, a small tuft of absorbent cotton may be coiled, and then used, as already indicated, for cleansing, and for treating the ear. When the cotton is to be removed, it should be twisted off in a direction opposite to that in which it was wound about the end, and not submitted to a flame, as has been done, greatly to the detriment of the instrument.

During all these procedures for removing small obstructions to a good view of the drum-head, the canal is supposed to be most carefully illuminated by light reflected from the forehead-mirror, and the operations performed by a skilled hand.

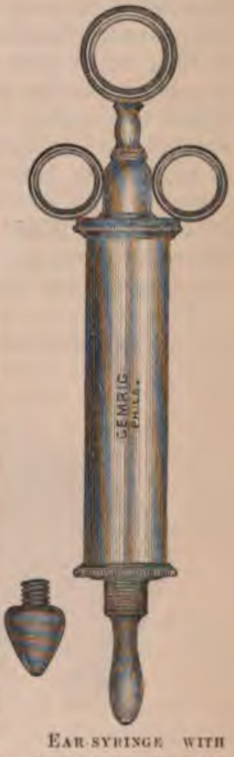
If the methods suggested should be inadequate to remove obstacles in the auditory canal, recourse may be had to syringing. The syringe should be carefully chosen; one that holds two fluidounces will be large enough, though both larger and smaller ones may be used. The syringe should work perfectly, being neither too loose nor too tight in the piston. A good ear-syringe is like that shown in the woodcut (Fig. 58). It holds two fluidounces, is made of fine brass throughout, excepting at its nozzle, where it is of hard rubber. A nozzle of such material is at once less cold to the ear, and less easily corroded by the various fluids syringed into and out of the ear; its shape, furthermore, renders it less likely to wound the meatus should the instrument slip or be pressed too firmly against the skin of the canal. To prevent slipping of the instrument, the two rings at the top of the barrel will be found of great efficiency. But brass syringes of this kind are expensive in this country, and being seldom called for by physicians, nor ordered for their patients, are rarely found ready made in the shops. There is, however, an excellent syringe for aural purposes always at hand in the hard-rubber, male syringe, No. 2. This is not only very good, but reasonable in price, so that any patient, even the majority of those seen in the infirmary, can buy it. At this point it may be said, unhesitatingly, that all forms of syringes sold in the drug stores and elsewhere, under the high-sounding name of "ear-syringes," are uniformly dear and as uniformly worthless.

Fig. 57.



Cotton-holder.

Fig. 58.



Ear-syringe with Accessory Conical Nozzle.

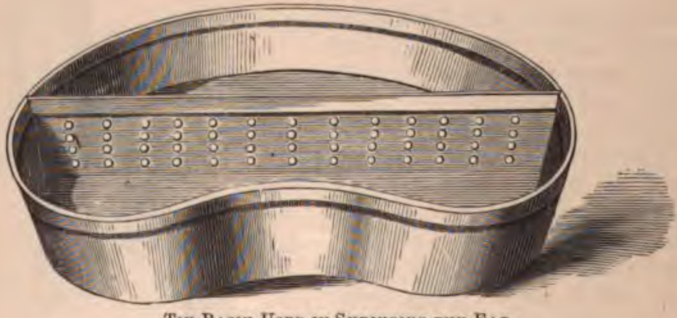
There is one specially bad form of syringe sold under the name of ear-syringe. It is made of hard rubber; the chief, if not the only danger in this instrument, lies in its slender point about a half-inch in length, in which the otherwise harmless conical nozzle is made to terminate. This point, the patient is told by the ignorant vendor, to insert into his auditory canal. This done, the slightest turn, either of the head or of the handle, will drive the point against the sensitive canal and wound it. Such a syringe, with its elongated tip, could, in the shallow meatus of a child, *reach and greatly injure the membrana tympani.*

The ear-douche of Dr. C. Fayette Taylor has been recommended by Dr. Roosa,[1] and that of Reynder, of New York, by Dr. A. H. Buck.[2] Reynder's douche is considered especially serviceable in treating children, because of the guards at the nozzle, to prevent introducing it too far into the auditory canal. Dr. Samuel Sexton,[3] of New York, has recommended a "soft-rubber aural syringe," as an instrument which may be safely placed in the hands of patients, where it is advisable to allow them to employ a syringe themselves. It is of Dutch manufacture, and in this country may be obtained of Ford, Caswell & Hazard, in New York.

Basin and Towel.—In syringing the ear a towel should be laid over the shoulder, and brought up as high as, and turned in over, the collar of the patient.

The basin or cup for holding the water and catching the return current from the ear may be of various kinds and patterns.

Fig. 59.



TIN BASIN USED IN SYRINGING THE EAR.

An ordinary kind is made of tin, the floor of which is kidney-shaped. (Fig. 59.) Such a basin fits very closely under the ear against the neck. But tin soon rusts and becomes useless. If the basin be made of a more durable metal it becomes more costly, but no more easily kept clean. A finger-bowl of glass or china is very good, because clean, cheap, and always at hand. A very simple, cheap, durable, and clean bowl may always be had by converting what is known in the china-stores as a bird's bath-tub, into a cup for holding water during syringing the ear. This little utensil has an oval bottom, the long diameter of which is 12 cm.; the short diameter 8 cm. The sides are 5 cm. high, and form an angle of about 95° with the base of the bowl. A cone-shaped basin like that suggested by Dr. F. M. Wilson,[1] of Bridgeport, Conn., is very useful if made of glass, and is not more than a foot long and six or eight inches wide.

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[1] American Otological Society, 1881, p. 511.

[2] Ibid.

[3] Ibid, 1883, p. 189.

Syringing the Ear.—In syringing the ear, cold water must never be used. Let the water used for syringing be pleasantly warm; some patients prefer it much warmer than others. Provided with a syringe as described, as well as with a receptacle for holding and catching the water, let the surgeon grasp the auricle between the thumb and forefinger of the left hand and pull it gently upward and backward. With the auricle thus held, let the syringe be emptied slowly but firmly into the auditory meatus. Point the syringe downward and forward toward the patient's nose. The current from the syringe should be thrown along the upper wall of the auditory canal, thus permitting the return current to take place along the floor of the canal.

In some cases considerable force may be used in throwing the current of water into the canal, as, for example, when it is desired to remove a foreign body from the fundus of the canal or when the canal is blocked up with a large and adherent wax-plug. I have found it decidedly advantageous to give to the syringe a gentle spiral motion as the current of water is going into the meatus. This impulse conveyed to the water will thoroughly wash off all adherent matters from the wall of the auditory canal.

Examination of the Nares and Fauces, Throat, and Eustachian Tube.—The inspection of the nares, fauces, and throat, and the examination of the state of the Eustachian tube by means of the Eustachian catheter, form a most important part of a complete aural examination. This is specially true of the more chronic forms of ear-disease, for to the parts named the chief treatment must be directed. The inspection of the nares may be made either from behind or in front; if in the former way, *i. e.*, by posterior rhinoscopy, the ordinary laryngeal mirror may be used, and the light either of the brightest day or of a large argand burner may be thrown on the laryngeal mirror by means of reflection from a large forehead-mirror.

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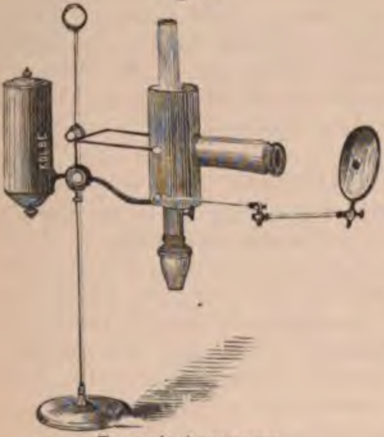
[1] Archives of Otology, 1880, p. 204.

This is at once convenient, inexpensive, and amply sufficient. If a more elaborate mode is desired, recourse may be had to the very elegant Tobold-apparatus.

Fig. 60.

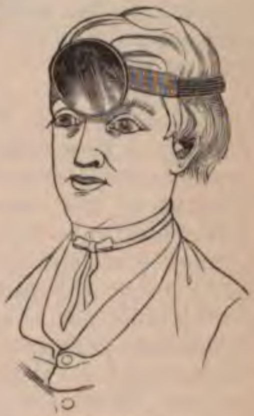


Tobold's Apparatus.

The former method, however, by means of the large forehead-mirror and the argand burner, is vastly preferable for the ordinary examination of patients. It is the means used in the large clinics of Vienna, and the student, as well as the practitioner, with the forehead-mirror once placed upon his head, may pass from one patient to another without the trouble and inconvenience which would attend transporting a cumbersome apparatus. All that is needed is an argand burner or a bright flame of any kind, unless bright daylight is chosen. I would say, however, that in using the laryngoscopic mirrors, a bright artificial light in a darkened room is by far the best. Bright daylight is too diffuse, illuminating other parts, and therefore not bringing into bold relief the parts specially under examination. Direct sun-rays, on the other hand, are too powerful when collected and thrown by the mirror into the ear or throat. It is a very easy matter to burn the parts thus illuminated by concentrated sun-rays.

Forehead and Hand Laryngeal Mirrors.—The forehead-mirror which is to be used in the above-named examination is 10½ cm. in diameter, and has a focal distance of about 30 cm. There is a small transparent spot at the centre, the glass being left unsilvered at that point. The metallic back which holds the mirror is bored at the centre so as to correspond with the central bare spot in the mirror. It is entirely unnecessary for purposes of inspection that the glass should be perforated at this point. Such a perforation adds nothing to the optical value of the mirror, but, as it endangers the glass, adds greatly to the cost. All the Vienna reflectors are now made unperforated, but unsilvered at the centre. The reflector should be provided at a point on the circumference with a small ball which fits into an adjustable socket on the plate of the forehead-band. The eye of the examiner may look through the opening in the mirror, in which case it is of course directly in the focal line, or the mirror may be so placed as to permit the surgeon to look either under or to one side of it and yet gain good illumination.

Fig. 61.



FOREHEAD-MIRROR.

The surgeon should provide himself with four sizes of laryngeal mirrors, two of each size entering into his set. One set should be marked and kept for examining specific or suspectedly specific cases, thus removing all danger of contagion from his more fortunate patients. No. 1 should be 1.50 cm. in diameter; Nos. 2, 3, and 4, respectively 1.75, 2, and 2.50 cm. in diameter. These should be fixed at an angle of 40°, to a slender but perfectly stiff shaft 12 cm. long, which is made to slide into a handle 10 cm. long, made of wood, bone, hard rubber, etc., bored its entire length. Into this hollowed handle the shaft of the mirror may be slipped and clamped at any point by a small lateral screw. The shaft supporting these mirrors may be bent upon itself at a very obtuse angle, in order to aid in a better inspection of the posterior nares in many instances.

Thus provided with the three factors of examination, a bright flame, a forehead-reflector, and a laryngeal mirror, let the surgeon place the patient on a chair with his back to the light, so that the latter shall come over the left shoulder of the patient. In this position the light will come towards the surgeon's right side, and somewhat from above if the lamp used is of ordinary height. If the larynx is to be looked at, the patient's head may be thrown very slightly backward, his mouth being open. The tongue may be depressed either by the surgeon or by the patient. In many cases all that is necessary in order to get the tongue out of the way is to have its tip seized between the index finger and the thumb of the patient's right hand and drawn outward. To render it less likely to slip from his grasp, the tip should be held between a fold of the edge of a towel or napkin. The laryngeal mirror should then be held for a moment with its glass surface, not its metallic back, over the flame in order to prevent the condensation of the breath on its surface. By holding the glass surface over the flame, not only is the mirror heated more quickly, but its silvered surface is thus kept from melting, for less heat is acquired in this way than if the mirror were heated by subjecting its back to the flame. This rule holds good for all cases in which the laryngeal mirror is to be used, whether for laryngoscopy or rhinoscopy.

In viewing the larynx the mirror should be introduced with the shaft on either side of the patient's mouth, rather than in the median line. Then, while the patient phonates the vowel sound *aa*, a view may be gained of the image of the laryngeal opening, in the small mirror held over the glottis. For all further explanation of laryngoscopy, the reader is referred to works on that subject.

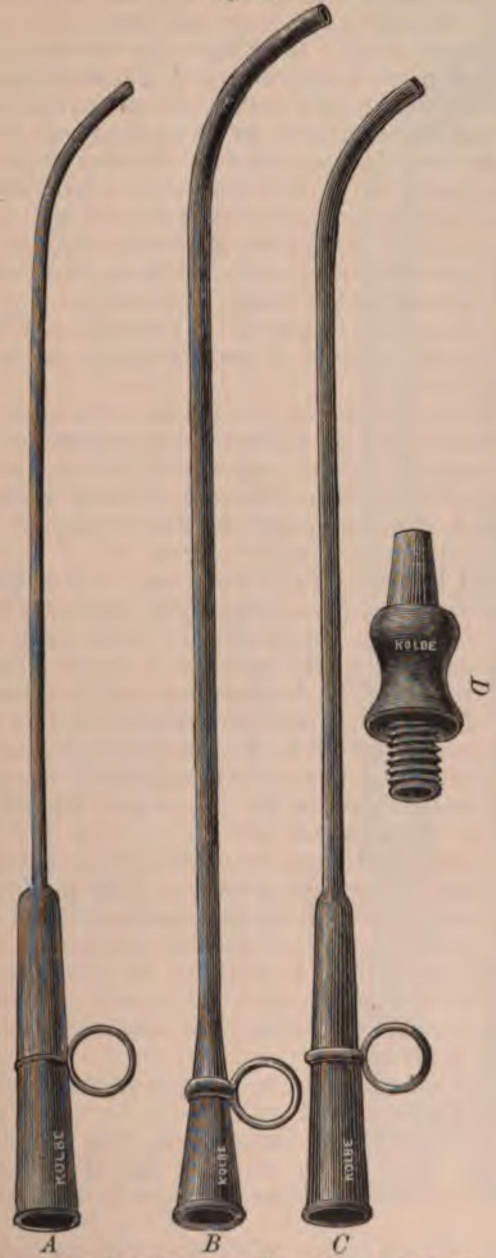
Rhinoscopy and Rhinoscopic Examination of the Mouth of the Eustachian Tube.—Rhinoscopy, though by no means indispensable to the aurist, becomes of far more value than laryngoscopy, on account of the view he may gain of the faucial end of the Eustachian tube by the rhinoscopic method. The instruments employed are similar to those described above, but the method of introducing the mirror is somewhat different. The patient's head should not be thrown backward; it must be upright or in some cases perhaps a little thrown forward. In rhinoscopy the tongue may be depressed by the examiner, but never by the patient. Here the mirror must usually play the part of the tongue depressor, though the latter may often be used with advantage. With the patient's mouth wide open and his tongue lying perfectly naturally within the limits of the teeth, let him try to breathe through the nose. Then, with the shaft of the mirror lying in the median line of the tongue, pass the former slowly toward the velum and behind it, pressing the tongue down as firmly as the patient will permit. Usually, all endeavors at getting a view of the posterior nares and vicinity fail most signally at first. This of course is due to the involuntary rising of the tongue and the consequent instability of the mirror, to which must be added the blurring of the mirror by the touching of its surface by the uvula.

After a few visits or even after repeated trials in some cases at the first visit, the tongue is more easily depressed, the patient gets more used to feeling the mirror in his fauces, and then a view may be gained of the posterior nares and the faucial extremity of the Eustachian tube.

There are, however, individuals in whom the velum is placed so near the posterior wall of the pharynx as to preclude any rhinoscopic examination. The surgeon soon learns to recognize these, and is wise in making no attempts at examining them with the rhinoscope.

Eustachian Catheters.—The ocular examination of the Eustachian tube ceases with the rhinoscopic view of the faucial extremity; beyond that point the examination becomes entirely aural, by means of the Eustachian catheter and the auscultation-tube. The Eustachian catheter consists of a tube of metal or

Fig. 62.



Eustachian Catheters of Hard Rubber.—Three sizes, *A*, *B*, and *C*. *D*. Hard-rubber ount of the air-bag, made to fit accurately into the large end of all catheters on the inciple of the ground joint.

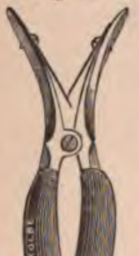
hard rubber, curved at the beak as seen in Fig. 62. The conical handle must be made so as to permit the end of the air-bag to fit accurately into it, and the ring upon the handle should be firmly attached to each instrument in the same plane with the circle of which the curved beak is an arc. By observing the position of the ring-indicator, one can always know the precise position of the beak of the catheter. Another important, though perhaps fortuitous, use of this ring is to hold a ticket with the name of the patient using the catheter. Every aurist should have a large number of all sizes of these catheters, so that each patient may have one to himself, and thus escape the danger of contagion. Instead of the ticket, each patient may have a long and slender paper box in which the catheter may be kept; but the importance of isolation of patients in this particular cannot be too strongly urged.

Not only has secondary syphilis been communicated by using the same catheter for all patients,[1] but catarrh, not dependent upon such a specific poison, may also be thus communicated.

Lucæ[2] suggests a bulbous widening at the proximal end of the catheter, which may be opened by unscrewing, and into which disinfecting cotton-wool may be placed.

Since it will be necessary to have catheters of different sizes, the diameter should vary from 1 to 3 mm., the size with a diameter of 2 mm. being the one most used, as it is best adapted to introduction into nostrils of average width. The hard-rubber catheter has the advantage of lightness and cheapness, and of not being easily corroded. Its cheapness renders it easier for the aurist to supply himself with a number of such instruments of all diameters. On the other hand, a virgin silver catheter is very flexible, and any need to change the curve of the beak is thus easily met in one instrument. But to have dozens of such instruments becomes expensive for the surgeon, though of course incumbent upon him if each patient is to have his own instrument. I have lately been using small catheters (Fig. 64, natural size) with great success in both adults and children.

Fig. 63.



Bonnafont's Nose-clamp.

The catheter may be held in position in the nostril by means of Bonnafont's nose-clamp.

Dr. Samuel Sexton[3] has devised a flexible rubber Eustachian catheter, firm enough to be very useful without a stylet. This instrument may be somewhat larger in diameter than those ordinarily used, for on being introduced through the nasal passages it adapts itself to the walls, readily collapsing when meeting with obstacles. It has proven itself of great value, in the author's hands, in cases of deviations of the septum and in hypertrophy of the turbinated bones. Two sizes are recommended by the inventor, one being 5 mm., the other 7 mm. in diameter. The thickness of the rubber is one millimetre. The catheter is eleven and a half centimetres in length. Its beak has the ordinary curve of other Eustachian catheters. Into the proximal end, a vulcanite canula is made to go, upon which is placed a button on the plane of the curve of the beak, as an indicator of the position of the beak when in the nasopharynx. The proximal end of the canula fits accurately into a special mount on the inflation-bag. The author uses this catheter just as he would any other catheter, with an ordinary inflation-bag, without the special bag and tubing recommended by the inventor.

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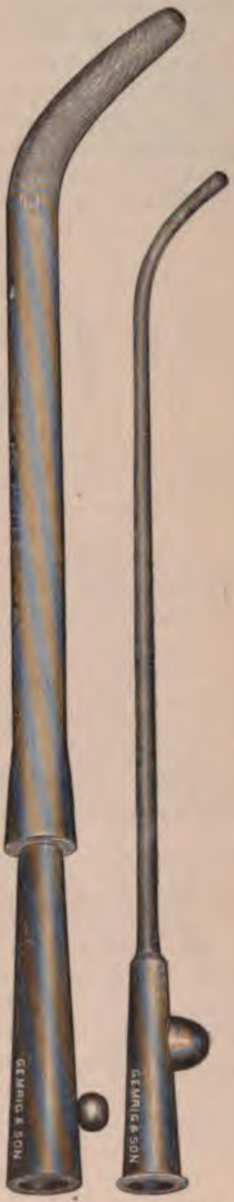
[1] A notorious occurrence in Paris, by which a number of people were inoculated.

[2] Archiv f. Ohrenheilkunde, Bd. xix. S. 132.

[3] Transactions of the American Otological Society, 1883.

Fig. 64.

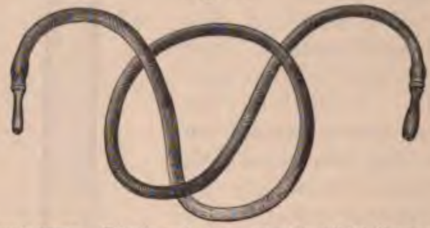


Sexton's Flexible Catheter. Small Hard-rubber Catheter.

The Auscultation-tube. — This instrument is the highly important adjuvant of the Eustachian catheter; in fact, in so far as the latter is of aid in an objective examination, it owes that power to the auscultation-tube. The latter consists of a yard of rubber tubing, 8 mm. in its outside diameter. Black rubber tubing is preferable, being more lasting and less sulphurous in odor than the ordinary domestic white rubber tubing. Upon one end of this tube there should be a white bone end-piece made to fit the surgeon's own ear; at the other end there should be a black end-piece, for the patient's meatus. In using the auscultation-tube, one end should rest snugly in the meatus of the ear catheterized, while the other end must rest equally well, though not too tightly, in the examiner's ear.

Let it be supposed, for example, that the patient's left ear is to be catheterized, and that the auscultation-tube is also to be used. Let the examiner place his end of the auscultation-tube in his left ear, bring the tube loosely around behind his neck and over his right shoulder, placing the other end of the tube in the patient's left ear. If the tube be thus supported, it is less in the way of the surgeon, and less likely to fall either out of his or the patient's ear.

Fig. 65.



AUSCULTATION-TUBE.—Black end for patient's, white for surgeon's, ear.

The method usually given in most works on aural surgery, is to allow one end to rest, for instance, in the patient's left ear, while the other end is resting in the surgeon's right ear. In such a case, not only will the tube hang down between the patient and surgeon and be in the way, but the mere weight of the auscultation-tube when thus suspended is sufficient to drag it out of place.

The Air-bag or Hand-balloon.—The general appearance of the hand-balloon is given further on, in the figure of Politzer's apparatus. The use of this bag is to force air through the catheter into the Eustachian tube and tympanic cavity. It is of the greatest importance that the end-piece at the point of the balloon-like bag, the so-called "mount," should fit accurately into the catheter, and, like it, be of hard rubber, Fig. 62, *D*. This hand air-bag is of the greatest importance and usefulness, for with it not only air, but medicated solutions, first placed in the catheter by a pipette, may be forced through the catheter and into the Eustachian tube. It is very uncommon that more impelling force is needed in catheterization of the Eustachian tube than can be exerted by means of the hand as it squeezes the air from this bag. Zaufal[1] suggests placing a capsule for holding a disinfectant in connection with the air-bag. During the expulsion of the air from the bag, great care should be taken not to force the axis of the bag out of line with that of the catheter, for, if this should occur, either by an upward or downward movement of the hand and wrist, the catheter if of hard rubber will be very apt to break, if of silver, to bend. In compressing the air-bag, no motion should occur, except in the fingers of the right hand or the hand employed in compressing the bag. A little practice will enable the operator to make only such a motion with the fingers, though at first there is an almost involuntary tendency to flex the hand laterally on the wrist towards the ulna, at the same moment the fingers are made to squeeze the bag. The bag must be removed from the catheter after each inflation, in order to renew the air in it. Any other form of inflation whereby this removal is obviated, tends to draw fluids from the nares into the catheter.

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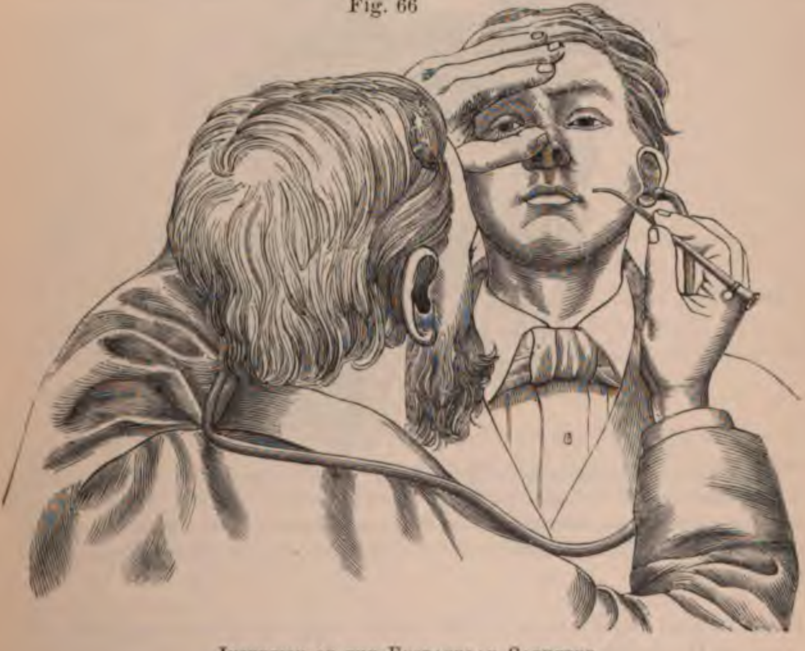
[1] Arch. f. Ohrenh., Bd. xvii. S. 1.

Catheterization of the Eustachian Tube.—Provided with the three instruments described in the preceding pages, viz., a catheter, an auscultation-tube, and a hand air-bag, the surgeon may endeavor to catheterize the Eustachian tube, *i. e.*, he may endeavor

Fig. 66

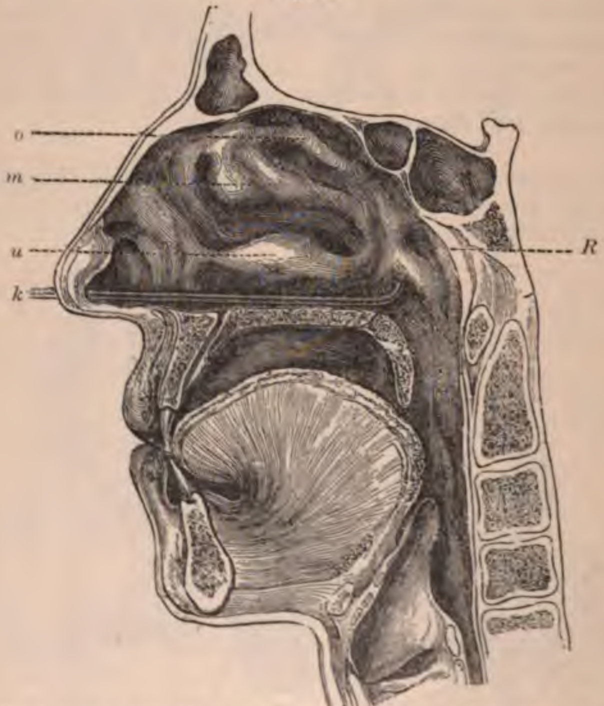


INSERTION OF THE EUSTACHIAN CATHETER.

to place the beak of the Eustachian catheter in the faucial end of the Eustachian tube, so as to enable him to force air into the latter, and if that be patulous, the air may pass into the tympanic cavity.

In catheterizing the Eustachian tube, the patient may sit or stand at the surgeon's option; as a rule, it will be more desirable for the patient to sit, since it is more comfortable for him, and will hence better enable him to hold still. Let the patient, then, sit down with the hips well back in the chair, and his spinal column and head erect. The latter may be placed against the wall or the back of the chair, should the latter come above the patient's head. Then, with the auscultation-tube adjusted as described, the surgeon should place the fore and middle fingers of his left hand on the patient's forehead a little above the root

Fig. 67.



INNER VIEW OF THE RIGHT HALF OF THE HEAD; ANTERO-POSTERIOR SECTION. (Gruber.) —*o*. Superior turbinated bone. *m*. Middle turbinated bone. *u*. Inferior turbinated bone. *R*. Rosenmüller's fossa, bounded in front by the cartilaginous lip of the tube; in front of the latter is the pharyngeal opening of the Eustachian tube, in which the catheter *k* is placed.

of the nose, and with his thumb he should lift up the tip of the patient's nose and hold it up until the catheter is well inserted.

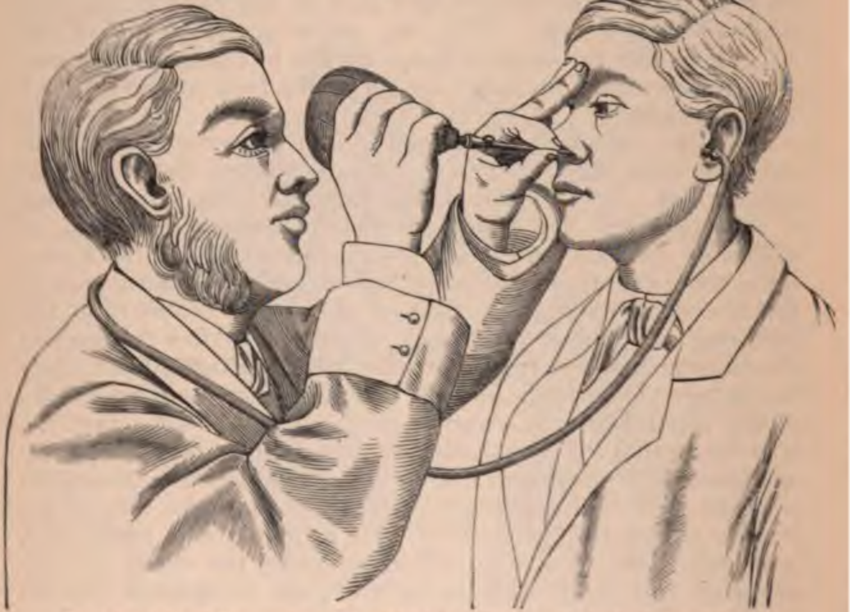
With the tip of the patient's nose held up as just described, let the surgeon grasp the catheter as he would a penholder, between the thumb and forefinger of the right hand, holding his hand down about as low as the patient's chin, towards which the palm of the catheter-hand should be turned. Now insert the beak of the catheter into the nostril corresponding to the ear to be catheterized, and with a compound upward and forward motion carry the instrument along the floor of the nose until the beak reaches the nasopharynx and at last touches the posterior pharyngeal wall. The ring at the proximal end of the catheter, which the surgeon keeps always in sight, should point directly downward upon the arrival of the beak of the catheter in the nasopharynx.

With the catheter's distal end at the posterior pharyngeal wall, the beak may be turned outward toward the ear to be catheterized. By this motion the beak will slip into the fossa of Rosenmüller. The mistake is usually made at this point, in supposing the catheter's beak rests in the mouth of the Eustachian tube, and unsuccessful attempts at inflation may be made. But in order to place the beak in the mouth of the tube, the following manipulation becomes necessary. After the beak of the catheter has been turned into the fossa of Rosenmüller, draw the catheter forward, letting the beak slip over the posterior lip of the Eustachian tube, and as soon as this is done turn the catheter so that the ring-indicator will point towards the ear catheterized, at an angle of 45°; at the moment this movement is made with the catheter, its beak slips into the faucial extremity of the Eustachian tube. Of course, this is easily said, less easily done; but with a little practice the touch is soon educated, and the Eustachian catheter can be inserted into the mouth of the tube with great ease.

Fixation of the Eustachian Catheter.—After the catheter has been thus put in place, let the thumb and forefinger of the left hand grasp the instrument close to the nose, while the remaining three fingers are braced above the root of the patient's nose, at the point formerly occupied by the middle and index fingers, during the elevation of the tip of the nose by the left thumb, and the insertion of the catheter by the right hand.

With the catheter thus fixed in position, and the auscultation-tube passing from the patient's ear to the ear of the examiner, the latter may grasp the hand air-bag and make inflations into the tube and tympanum. If the Eustachian tube is pervious, air will be heard to enter it with more or less force. As a rule, two or three inflations with the contents of the air-bag will be sufficient, both in force and in number, to properly and safely ventilate the middle ear. When considerable stimulation is demanded by the atonic condition of the muscles and mucous membrane, numerous inflations, even as many as a dozen, may be made with entire safety. In using the Eustachian catheter, the only danger is from emphysema; but this can never occur unless the mucous membrane has been abraded by the unskilful introduction of the catheter. Even should such abrasion occur, emphysema might not be produced unless very powerful inflations were to follow. The two fatal cases which occurred, during inflation, in the practice of a well-known London quack, were caused, probably, by the use of a powerful air-pump; but air-pumps are no longer used, or at least very rarely, by responsible men. There is certainly no record of a case of death from emphysema resulting from gentle inflation made by the hand air-bag.

Fig. 68.



Fixation of the Eustachian Catheter in Position, Preparatory to Inflation.

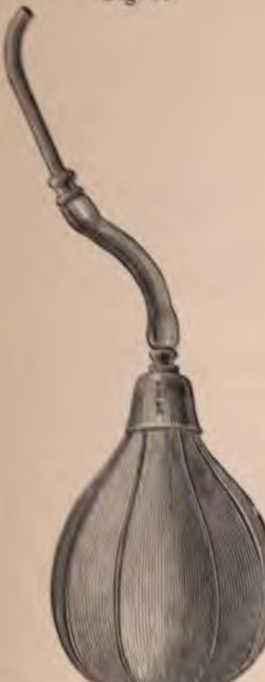
Where death has occurred from emphysema of the pharynx and the parts about the larynx, the fatal result has most probably been brought about just as it is in œdema of the glottis. The treatment, therefore, should have been the same and just as prompt in the former as in the latter malady, *i. e.*, free scarification of the puffed-up parts in order to permit the air to escape from the cellular tissue beneath the mucous membrane. As the Eustachian catheter is in constant use all over the world, and as the only cases of death which were ever suspected of being caused by its use occurred at the hands of a quack, the latter, and not the instrument, should be held accountable for the unfortunate result.

Death in cases of emphysema produced in the above way might be due to pneumothorax. Voltolini proved this to be the cause of death in a dog, into the naso-pharyngeal region of which he first introduced a catheter, then a wire, by which he wounded the mucous membrane of the parts near the opening of the Eustachian tube. By a powerful introduction of air he produced sudden death, and a post-mortem examination of the animal showed that air had entered the pleural sac and produced collapse of the lungs. There was no emphysema of the vocal cords nor of the larynx.

Other Methods of Catheterization.—Josef Gruber recommends a somewhat different method from the foregoing. Thus, after the catheter has been introduced through the nose and has reached the hinder wall of the pharynx, let the instrument be drawn straight outward until its curved beak lies against the soft palate. Then push the catheter a short distance (from half an inch to an inch) inward, and turn the beak outward towards the ear. It will be found that, as a rule, the beak will slip into the mouth of the Eustachian tube. A somewhat less complicated method is that known as Löwenberg's. In this method the catheter is introduced in the usual way through the nose until it reaches the posterior wall of the pharynx. Then let it be turned inward and drawn forward until the curve of its beak touches the septum narium. If now with a downward turn the point of the catheter be made to describe a semicircle, the beak will usually slip into the mouth of the Eustachian tube. All of the above efforts at insertion of the point of the catheter into the mouth of the Eustachian tube, as well as inflation, may be greatly helped by an act of swallowing on the part of the patient at the precise moment the instrument is to be inserted into the mouth of the tube, or just as the air-bag is emptied through the catheter.

Politzer's Air-bag and Method of Inflation of the Eustachian Tube and Tympanic Cavity.—Dr. Adam Politzer has given to the profession a most valuable means of inflating the nasopharynx, Eustachian tubes, and tympana. The instrument bears his name, being known as Politzer's air-bag, and the method of its employment is known as Politzer's method of inflation. The instrument consists chiefly of an ordinary air-bag such as is used for forcing air through the Eustachian catheter. Instead of the conical tip of the ordinary hand air-bag, the instrument devised by Politzer is supplied with a somewhat bulbous tip, to which is attached a piece of black rubber tube 8 cm. long, which forms the pliable connection between the air-bag and the nose-piece. The latter piece is made of hard rubber, and varies from 3 to 4 mm. in diameter. It is curved slightly at the beak and resembles at this point a coarse Eustachian catheter. In fact, one may extemporize a Politzer's apparatus by attaching an ordinary hard-rubber catheter to the hand air-bag. But in this case the disadvantage is in the stiffness of the catheter and its great liability to snap in half.

Fig. 69.



POLITZER'S AIR-BAG FOR INFLATING THE MIDDLE EAR.—(One-third natural size.)

Politzer's method of inflation depends upon the physiological fact that, at the moment of swallowing, the velum palati rises and thereby draws the anterior wall of the Eustachian tube from the posterior. At this moment the faucial extremity of the tube is so patulous that air forced through the nares, not being able to pass downward into the fauces and mouth, because the velum palati prevents it, will by following the course of least resistance pass into the tube and usually into the tympana.

In order to accomplish this result at the desired moment, the patient is instructed to take a sip of water and retain it in his mouth until told to swallow. After the water has been thus taken, let the surgeon place the curved nose-piece into either nostril and compress the nostril in front of the nose-piece. The usual error is made in trying to compress the ala of the nostril down upon the nose-piece. This is very painful to the patient, is apt to make him jump, and thus the surgeon is defeated. The index finger should compress the other nostril so that no air from the bag shall escape outward through the nose. The point of the nose-piece should be directed outward against the ala, rather than inward against the bony septum. If the latter is done, and it usually is the mistake of beginners, the septum will be painfully pressed if not wounded, and bleeding from the nose may be the very undesirable result.

In using this method of inflation one ear of the patient may be connected by the auscultation-tube to the ear of the surgeon; but this is by no means necessary, since, as a rule, when the method is properly carried out, a peculiar resistance or recoil ensues in the inflation-bag, which the surgeon soon learns to recognize.

By the very nature of the physiological process called to aid in Politzer's method of inflation, both ears are likely to be inflated at the same time. The fact that one ear cannot be isolated at will during this mode of inflation should be borne in mind. If for any reason such isolation on the part of either ear should be demanded, the surgeon must resort to the catheter. The force of the Politzer inflation, however, can in any case be augmented on either side by pressing the finger firmly into the canal of the ear opposite to the one it is specially desired to ventilate. By some, it is supposed that this latter modification is aided by holding the head over towards the shoulder opposite to the ear which is to receive the greater amount of inflation. As in such a position the ear on the upturned side is highest, it is to be supposed that the air may take its course more readily toward that ear than the one turned downward and firmly stopped by the finger. Instead of swallowing water to insure the elevation of the palate, the surgeon may command the patient to say "hick" or "hack" (Gruber), or "a a" (Lucæ), or he, the patient, may simply puff out his cheeks with closed lips (E. E. Holt); thus forcing the root and dorsum of the tongue against the velum, or the patient may puff air from his lips, as suggested by J. O. Tansley. The latter method, however, is not an agreeable one for the operator, standing, as he does, in front of the patient. In very young or unreasonable children who cannot or will not swallow, but cry, Politzer's method is invaluable, for, as he taught long ago, the more the child cries the more firmly does it lift up the velum palati and favor the surgeon's attempts at inflation of the tympana.

CHAPTER II.

SOUND, HEARING, AND TESTS OF THE LATTER.

Sound is motion imparted to the auditory nerve by undulations in the air. A shock from a vibrating body, conveyed to the air immediately surrounding it, is propagated by a wave of undulation, not of progression, to other particles of air. This wave of sound at last reaches the membrana tympani, and transmits itself, by the aid of the latter and the ossicles of hearing, to the fluid of the labyrinth and to the nerve of hearing.

Hearing is the perception of such sonorous undulations of the air. It implies a free access of air to the drum-head, a perfect oscillation to and fro of the chain of ossicles, unimpeded movement of the stapes in and out of the oval window, and a normal percipient organ in the labyrinth. If any of these requirements is wanting, the hearing will be defective, the degree varying from hardness of hearing to total deafness. The vibrations in the air may be periodic or irregular, *i. e.*, they may be of equal length and duration, or they may be unequal and crowded upon one another in the greatest confusion. The former would produce musical sounds or *tones*, and the latter *noises*.

Intensity, Pitch, and Quality.—Frequent allusion is made in acoustics to the intensity, pitch, and quality of sounds. The first depends on the breadth or amplitude of the vibration. When a wire is first set in vibration, the extent of the excursion it makes, backward and forward between its fixed ends, is visibly much wider than it is as it gradually ceases to vibrate. During these wide excursions the sound is strongest, but it grows weaker as the vibrations become narrower. It must, however, be kept in mind that only the width, not the number of vibrations, has diminished, and therefore the pitch of the note remains the same, though weaker.

Pitch depends simply upon the number of vibrations emanating from a sounding body in a second, thus a high pitch means numerous vibrations in a second, low pitch implies but few.

Quality or Clang-tint.—The quality of a sound, also called its clang-tint or timbre, depends upon the peculiar kind of vibrations and the manner of their occurrence. The difference between one musical quality and another depends entirely on the presence and the strength of the partial or over-tones.

Partial or Over-tones.—If a wire be stretched between two points, it can be made to vibrate as a whole, or it can be made to divide itself into a number of equal parts. The note emitted by the wire when vibrating as a whole is called its fundamental note. The notes represented by the vibrating subdivisions of the wire are termed its partial, secondary, or over-tones. All vibrating bodies or instruments, therefore, give out, besides their fundamental notes, their over-tones, or harmonics, as they are also termed, and it is the general admixture of these, with their varying number and strength, which goes to form the quality peculiar to a given sound. This is called timbre by the French, and Klangfarbe (clang-tint) by the Germans.

System of Indicating Musical Notes by Letters.—In otology, frequent reference is made to musical notes. This is generally done by citing the letter used by the Germans to designate a particular note. This is a system whereby the position of a note in the scale, and hence the number of its vibrations in a second, is very easily shown. It is accomplished by using different letters for the notes in an octave, and different kinds of type, or adding coefficient numerals to the same type, to indicate the octave to which the notes belong. As it is of the greatest importance that the reader should know at a glance the relative position in the musical scale of the notes thus cited, in the examination of the ear and in recording the hearing, the following table, as found in Helmholtz's celebrated work,[1] is here given.

	C_{I}–H_{I}	C–H	c–h	c^{I}–h^{I}	c^{II}–h^{II}	c^{III}–h^{III}	c^{IV}–h^{IV}
C.	33	66	132	264	528	1056	2112
D.	37.125	74.25	148.5	297	594	1188	2376
E.	41.25	82.5	165	330	660	1320	2640
F.	44	88	176	352	704	1408	2816
G.	49.5	99	198	396	792	1584	3168
A.	55	110	220	440	880	1760	3520
H.	61.875	123.75	247.5	495	990	1980	3960

The letters at the top of the column indicate the note and the octave in which it lies; the numerals, the number of its vibrations per second.

According to Helmholtz, the deepest note used in orchestral music is one of $41\frac{3}{4}$ vibrations in a second. In pianos and organs the lowest note is generally one of 33 vibrations per second, but some grand pianos are constructed to give out a note as low as $27\frac{1}{2}$ vibrations. The musical character of such low notes is very imperfect, especially those lower than E, with

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[1] "Die Lehre von den Tonempfindungen," Braunschweig, 1870.

41.25 v. s. They become musically useful only when sounded with their octave higher. Some pianos are made to give out notes as high as a^{iv}–c^{v}, *i. e.*, from 3520–4224 vibrations in a second. The highest note used in orchestras is the d^{v} of 4752 vibrations, produced by the piccolo, a kind of flute. Beyond these limits the notes become shrill, disagreeable, and, to some ears, absolutely painful.

By the same authority it is held that, only those notes lying between 40 and 4000 vibrations in a second, or within seven octaves, are of real musical value. Yet those lying between 20 and 38,000 vibrations a second, or within eleven octaves, may be perceived as musical notes. In this respect, the ear is far superior to the eye, for the latter rarely perceives vibrations of light extending much over an octave.

The so-called "Deaf Points" of the Ear.—Dr. V. Urbantschitsch[1] pointed out, some time ago, a phenomenon connected with the organ of hearing. He has shown there are some points near the ear, at which a vibrating tuning-fork cannot be heard, and he calls these "deaf points." By following his directions any one can verify his experiments. Thus, if a tuning-fork held perpendicularly in front of the ear be started from the lower edge of the zygoma and moved backward towards the occiput, so that the upper end of the fork passes the lower end of the tragus, two points will be reached where, though the vibrations of the fork are felt by the fingers, the ear will for a moment perceive no sound, until this deaf point is passed. The fork is then heard for a short interval until it reaches the second deaf point, after which the vibrations are heard once more as the fork is gently passed on its way backward towards the occiput. The same points are peceived if the vibrating fork is passed in the opposite direction, *i. e.*, from behind forwards in the line above described.

The position of the first point is at the lower end of the tragus; the second, is at a point where the helix intersects the line of motion given above. If a tuning-fork held horizontally be passed vertically upwards before the ear, the same kind of deaf point is found in the region of the crista helicis. This phenomenon remains the same whether the tuning-fork is passed in the same line, at a greater or less distance from the ear. A further investigation led to the discovery of so-called "deaf fields" in the form of two small triangles, the first of which lies in front and above, the other behind and above. The apex of the anterior triangle lies at the lower end of the tragus, already spoken of, from which point the sides diverge gradually towards the frontal and parietal bones. The general tendency of these lines is upward; at the frontal protuberance they are 2–3 cm. apart. The apex of the second triangle is at the lobule of the auricle or near the lower part of the helix. The sides diverge in the direction of the lateral surface of the parietal and occipital bones. At a point corresponding to the uppermost part of the helix they are about 2–3 cm. apart.

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[1] Centralblatt f. d. Med. Wissensch., No. 8, 1872; M. f. O., No. 2, 1872.

Dr. Emil Berthold,[1] of Königsberg, explains these phenomena as entirely unconnected with the physiology of the ear, but entirely due to the interference of the vibrations of the fork. Thus, if a vibrating tuning-fork is moved slowly past the mouth of a bottle, the fundamental note of which corresponds to that of the fork, the air in the bottle will be set into consonance with the note of the fork excepting at the moment when the sound-waves entering the mouth of the bottle are quenched by interference. This will happen, says Dr. Berthold, when the first tine of the fork has just passed the inner edge of the bottle, and again when the second tine has almost reached the inner edge of the bottle, *i. e.*, at two points which correspond to the tragus and the helix.

Sound and Color.—Dr. J. A. Nussbaumer,[2] of Vienna, has communicated some very interesting facts relating to subjective perception of color produced in himself and in his brother by objective perception of sound. The note "small e" on the piano produces in the former the subjective perception of the color of dark yellow; in the latter the impression of dark blue. There are some colors which no note calls up; blue, yellow, brown, and violet are most frequently produced. There is no red nor green, nor perfectly black and white in any notes. Dr. Nussbaumer, however, perceived green once, upon hearing suddenly a peculiar noise. Colors are also perceived by him in dreams if noises are dreamed of. The author endeavored to represent the subjective tint of the fundamental note as a mixture of single tints corresponding to the separate partial tones, and he was in a measure successful. Dr. J. Baratoux[3] explains these peculiar phenomena by the supposition that the color-centre may be aroused not only by the retina, but by other senses. Thus, it can be supposed that certain cells of the auditory centre are connected with elements of the color-centre, so that by stimulation of such auditory cells, a certain perception of color will be aroused.

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[1] Monatsschrift f. Ohrenheilkunde, No. 5, 1872.

[2] Ueber subjective Farbenempfindungen die durch objective Gehörempfindung erzeugt werden, Wiener Med. Wochenschr., Nos. 1, 2, 3, 1873.

[3] L'Audition Colorée, Revue Mensuelle de laryngologie, etc., No. 3, 1883.

TESTS FOR HEARING.

Aerial and Bone Conduction of Sound.—Sound is normally conveyed to the auditory nerve by the passage of sound-waves into the external auditory canal, and by the oscillations of the membrana tympani and ossicles which these sonorous waves produce. Sound may also be conveyed to the auditory nerve by the vibrations it produces in the osseous tissues of the head; the waves of sound, in the latter instance, being conveyed directly to the walls of the labyrinth, and thence to the terminal filaments of the acoustic nerve. The former mode of conveyance of sound is called aerial, and the latter mode, bone-conduction of sound. In bone-conduction it is probable that some of the waves of sound falling on the ossicles set them in motion, and thus some of the sound is conveyed to the perceptive apparatus in the labyrinth.

Normal Hearing.—No precise standard of normal hearing has ever been defined. The normal ear hears all sounds that fall on it; but it cannot be said, *à priori*, where good hearing ceases and defective hearing begins, for in many senses these are relative terms.

The sense of hearing must be regarded as composite, *i. e.*, it consists in the ability to hear a number of different sounds both periodic and irregular in their vibrations. Such sounds can be heard singly or together. Hence, the sense of hearing may be said to lie in a collection of nervous elements, which can be aroused separately or together. The latter is shown by the well-known fact that more than one sound can be heard at the same time.

The Watch.—Some form of watch-work or ticking apparatus is an old and ready means of testing the hearing. In this way the pocket watch, mantel clock, metronome, or an especially contrived ticking machine has been called into requisition. But the watch being a low form of musical instrument, according to Oscar Wolf,[1] at best giving forth only two poor notes, not easily determinable in pitch, can never have a wide application as a test. When using a watch as a means of determining the hearing, the test is being accomplished with only one or at most two notes. Now if a defect in the conducting or in the perceptive auditory apparatus interfere with hearing notes given out by the test in a particular case, then the watch will not be heard, or but imperfectly, whereas a watch, the notes of which are of a different pitch, might be heard. Hence it is that the watch as a test so often fails.

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[1] Archives of Oph. and Otol., vol. iv.

Its inferiority as a test depends, therefore, on the fact that in using it the power of the ear to conduct or to perceive only two notes of the entire musical scale, is placed on trial. But as far as it goes, the watch may be of value as a test, especially if its notes be made to come out with intensity and if also the form known as a stop-watch be used.

The simplest and most convenient form of watch-test is the ordinary pocket timepiece. When using it as a means of testing the hearing, the watch should be brought from a point where it is not heard, gradually towards the ear, until the ticking is perceived by the patient, or until positive inability to hear it, even on contact with the head, is discovered.

The distance at which the watch used is heard by the normal ear, should be known by the examiner. This distance may represent the *denominator* of a fractional form of expressing the hearing power: the numerator, the distance heard in a given case.

This is a suggestion of Dr. J. S. Prout, of Brooklyn, and a most valuable one it is. Thus a watch is heard by the normal ear 60 inches, and by a diseased ear in a given case 20 inches. The record in such a case would be expressed by the fractional formula $\frac{20}{60}$ in.

Dr. Roosa employs this formula with modifications, as, when the watch is heard only on contact, then $\frac{\text{c}}{60\text{ in.}}$ would express this condition. $\frac{\text{p}}{60\text{ in.}}$ and $\frac{\text{o}}{60\text{ in.}}$ would express respectively that a given watch is heard only on pressure or not at all.

It is not intended that these fractional expressions should be reduced, for in that case it would be less awkward to say instead of $\frac{20}{60}$, $\frac{1}{3}$. The idea is to let the fraction stand as above, so that the denominator shall show at a glance the exact distance the watch is heard by the normal ear.

A somewhat less simple method is given by Dr. Knapp;[1] thus, if a watch normally heard 10 feet be heard only 3 inches, then the hearing may be recorded as $\frac{3}{12.10} = \frac{1}{40}$ of the normal standard. Fractions of an inch are placed, in this method, either in the numerator, as $H = \frac{1:2}{12.10}$, or the unit is to be left in the numerator and all other numbers in the denominators, as $\frac{1}{2.\ 12.\ 10}$, which shows the watch is heard at half an inch.

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[1] Archives of Oph. and Otol., vol. iii. Part I. p. 220.

In order to avoid a mathematical operation I have found it useful to express the formula perhaps a little more arbitrarily, thus $\frac{\frac{1}{2}\text{ in.}}{60\text{ in.}}$, which shows that the watch of 60 in. is heard only ½ in. Thus the original idea is fully maintained, and the record can be kept by the least mathematical.

The Stop-watch.—Of all forms of watch-work for testing the hearing the most useful is the stop-watch. Besides its power as a test, there is also in it the means of finding out whether the patient really hears the sound of the watch, or whether he *thinks* he does, because he knows a watch is being held before his ear. This means is often the first to declare that the patient's statements respecting his subjective impressions of sound are unreliable.

If the ticking of the watch can be alternately stopped and set going at the will of the surgeon, errors of observation on the part of the patient may be detected. The same end has been gained by alternately holding and removing a diaphragm of paper between the ear and the watch.

Children, as a rule, give erroneous statements as to their ability to hear a watch. The reliability of their statements can soon be decided if a stop-watch be used, for they are obliged then to show whether they are aware of the stopping and the going on of the apparatus. A stop-watch for this purpose may be constructed to tick with great intensity. The form I have used for some years can be heard sixty feet by the normal ear, in the open air.

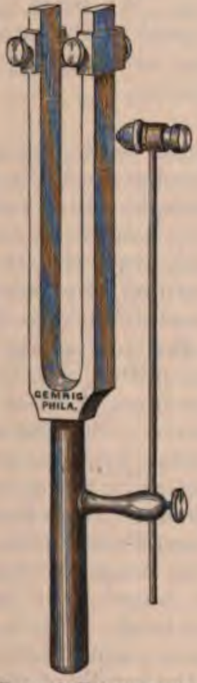
In some cases, even while the ticking continues, the patient will state that he no longer hears the sound of the watch. This may be a perfectly true statement, and is explained by the fatigue of the diseased ear. As will be shown later, some ears affected by chronic aural catarrh manifest this tendency to grow fatigued and to cease to hear a sound, while listening attentively to it.

As a test for bone-conduction, the watch is limited both by the age of a patient and by the weakness of its impact. The latter may be overcome by having the ticking apparatus so constructed as to give its sounds with great intensity.

The Tuning-fork.—There are several forms of tuning-fork used in making tests of the hearing. The best results are obtained with a large instrument giving a powerful fundamental note. A very beautiful instrument is the tuning-fork devised by Dr.

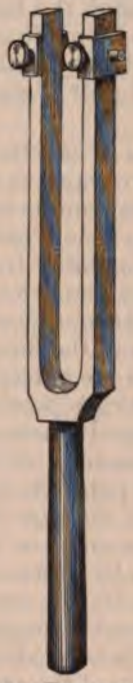
C. J. Blake, in which the force setting the fork in vibration is obtained by means of a steel hammer padded with rubber. The handle of the hammer is adjustable at any point in its length, by which means the blow can be weakened or strengthened as desired. (Fig. 70.) The clamps with which all tuning-forks should be provided are for damping the over-tones of the instrument.

Fig. 70.



Blake's Tuning-fork.

Fig. 71.



Clinical Tuning-fork.

An instrument which has given satisfaction, and which can be supplied at moderate cost, is the clinical tuning-fork. The instrument is set in vibration by gently tapping it against any firm object, at one of the short stems on the clamp. (See Fig. 71.)

While the force thus applied is not always the same, practice will enable the surgeon to apply nearly the same amount of force in every case. The instrument possesses the advantage of great convenience and simplicity; it is 26 cm. long, and gives out a full, deep note, free from discordant over-tones, when the clamps are properly adjusted at the points. By altering the position of the clamps the fundamental note is changed.

Prof. Politzer[1] has devised an acoumeter, consisting of a hard-rubber tube 4 centimetres in length, in which is a steel cylinder 28 mm. long and 4 mm. in diameter. Above the latter is a small hammer, which is made to strike the steel rod by touching a spring. There is attached to one side of this instrument a small pedestal, which supports the acoumeter against the head, when it is desired to test the perceptive power of the auditory nerve through the bones of the cranium. All these instruments are said to be made alike, and are attuned to the note c^{ii}. The inventor claims for this instrument the advantage of supplying a standard unit of measurement of hearing.

The Use of the Tuning-fork in Diagnosis.—The tuning-fork is used in two ways, as a test of hearing and as an aid in diagnosis. 1. By aerial conduction of its vibrations, in which instance, the instrument being held near the ear, its sound reaches the conducting apparatus in the most favorable way, viz., through the air. 2. By bone-conduction, as it is termed, in which the vibrations of the tuning-fork are communicated chiefly directly through the tissues of the face and cranium to the conducting apparatus, and also to the perceptive organs. The normal ear, in a normal skull, is always possessed, at the same time, of these two ways of sound-conduction to the auditory nerve. But the normal ear is not conscious of this ability to hear by bone-conduction, because it perceives sound so much better by aerial conduction than it can through the bones of the head. Therefore, it is not until the normal or aerial mode of sound-conduction is interfered with by obstructive disease in the sound-conductors, that the ear, in its abnormal state, becomes conscious of the conduction of sound through the tissues of the head. This is especially marked when the vibrations of sound are communicated directly to the bones of the cranium by placing the handle of the vibrating tuning-fork upon the vertex, or glabella. Then, if aerial conduction is obstructed, the auditory nerve still retaining its function, the affected ear becomes conscious of a loud volume of sound from the tuning-fork vibrating on the vertex, or glabella. These phenomena are, however, only those of modified sound-conduction, and from them can be drawn, for the most part, conclusions applicable only to the condition of the conducting apparatus of the ear, but not to that of the nerve.

According to Politzer,[2] E. H. Weber first drew attention to the fact that a vibrating tuning-fork, the shaft of which was in contact with the bones of the head, was heard better in that ear, the external auditory canal of which was stopped by the finger.

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[1] K. K. Gesellschaft der Aerzte, Wien, March 2, 1877.

[2] Wiener Med. Wochenschr., 1868.

This phenomenon was long unexplained, until Mach, on purely theoretical grounds, advanced the view that the reason of this lay in the hinderance offered, by the finger in the auditory canal, to the escape of the sound-waves from the ear. Politzer, having in mind this phenomenon, thereupon made a series of experiments upon the human ear, and came to these conclusions:

The above-named augmented perception of sound upon closing the external auditory canal, is due to (*a*) the *reflection* of sound-waves from the bones of the head, through the air of the external auditory canal, to the membrana tympani and auditory ossicles, and (*b*) to the *hinderance* which the sound-waves, passing from the bones of the head to the labyrinth and tympanic cavity, meet in escaping from the ear. In the latter conclusion, Mach and Politzer are in entire accord.

Age does not seem to have much to do with the ability to hear by bone-conduction, provided that the fork used is powerful. If the auditory nerve perceives at all, individuals over eighty years of age usually hear the fork vibrating on the vertex. But doubtless it requires powerful vibrations to make themselves felt through the head-bones of the aged. When bone-conduction in the aged seems to be impaired, it is due probably, as Moos has suggested, to a diminished sensibility of the auditory nerve.

Then, too, the musical education or sense of the patient, as well as the perceptive powers, must be taken into consideration. If not, hearing will often be confounded with feeling.

It has been found that deaf-mutes might, to some, appear to hear the tuning-fork vibrating on the vertex, were it not known that what they perceive in such conditions, are vibrations at the diaphragm.

In the case of a brakeman, struck over the head as the train of cars on which he was standing passed under a bridge, the ears, though entirely and suddenly made deaf to all external sounds by aerial conduction, appeared to hear the tuning-fork vibrating on the vertex. But in this instance it seems rational to conclude that the fork's vibrations were *felt* rather than heard.

Three-limbed Auscultation-tube.—In addition to the patient's statements, there has been advised the use of a three-limbed auscultation-tube,[1] two arms of which should be placed in the auditory canals of the patient, and the third in the ear of the observer. If now, a vibrating tuning-fork be placed on the vertex of the patient, the auscultator can perceive the sound of the fork streaming from the ears of the patient. By alternately pressing the two arms of the tube, connected with the patient's ears, the auscultator can further learn from which ear the greater amount of sound comes. Of course, it is evident that more sound-waves must come from the less obstructed ear. The latter will, as a rule, be the better hearing ear, unless its fellow is deaf, not by obstruction in the sound-conducting parts, but by paralysis of the nerve.

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[1] Moos, Klinik der Ohrenheilk., p. 42, 1866.

The Interference-otoscope. — A somewhat similar instrument, though one used in a different way, has been devised by Lucæ,[1] of Berlin, and named by him the interference-otoscope. This instrument consists partly of a double stethoscope of Scott Allison, the limbs of which, intended to fit snugly into the auditory canals of the patient, are about eleven inches long. At the junction of these symmetrical arms is placed a T-shaped glass tube from the portion of which representing the standard of the letter, passes a rubber tube to a collector of sound, half paraboloid in shape. Here the vibrating tuning-fork is stationed. To the other end of the cross-piece of the glass tube is fixed the rubber tube two feet long, for the auscultator.

Lucæ's experiments in this direction were based on the fact that sound-waves, falling on a stretched membrane, are only partly taken up and transmitted by it. The supposition then naturally follows that sound-waves entering the external auditory canal, are only partly transformed into the peculiar pendulum-like, to-and-fro movements of the sound-conducting membrana tympani and auditory ossicles. According to the greater or less extent to which the membrana tympani takes up the sound-waves falling on it, this so-called reflection of the waves of sound will vary in amount. The investigations made tend to elucidate experimentally this reflection of sound, and the probable influence on it of the changes of tension in the sound-conducting apparatus; also, from a study of these phenomena of reflection of sound-waves, an endeavor is made to obtain an objective expression of the sound-waves taken up by the ear.

The physical experiments show that: 1. A stretched and inclined membrane of India-rubber, placed in an artificial ear made to represent as closely as possible the natural organ, will reflect a certain quantity of the sound-waves entering the external auditory canal. 2. Closure of the Eustachian tube increases slightly this reflection. 3. Increased tension of the membrane shows that the reflection is directly proportional to the tension. 4. This outward reflection of sound-waves is greatest whenever the tension occurs simultaneously with considerable changes in density in the air contained in the tympanic cavity.

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[1] Archiv fur Ohrenheilk., Bd. iii., 1867.

In order to make practical application of these laws, Lucæ devised his interference-otoscope, by which the relative amounts of reflection from both ears could be determined in a given case.

The results obtained by the use of the interference-otoscope (in connection with normal ears) are thus summed up by Lucæ:

1. The normal organ of hearing reflects a certain amount of the sound-waves entering the external auditory canal.

2. The reflection increases in all changes of the sound-conducting apparatus, especially in the middle ear, which directly or indirectly lead to an increased tension of the membrana tympani.

3. The examination of those with normal hearing, by means of the interference-otoscope, shows that the different sensibility of both ears for the same tone is caused by the different amounts of reflection brought about by different tensions in the two sound-conducting apparatus.

Respecting the diseased ear, the conclusions are:

1. The interference-otoscope shows in the majority of cases of disease, in analogy with the observations made on those with normal hearing, a *greater* reflection of sound from the worse ear.

2. This is found in a number of cases in which the ear-mirror and the Eustachian catheter reveal disease in the external or middle ear.

3. In the numerous cases of ambilateral chronic catarrh of the middle ear, without perforation of the membrana tympani, the examination usually reveals a *greater*, though sometimes a *less*, reflection from the worse ear; in the latter instance, a simultaneous disease of the labyrinth may be supposed and the prognosis becomes much less favorable.

4. The greatest utility of this method of auscultatory examination lies in the not uncommon cases in which all other diagnostic means fail to show morbid changes in the external and middle ear; here, too, as a rule, a stronger reflection is observed on the worse side, which points to a deep-seated disease of the sound-conducting apparatus. Only in some few cases does the examination reveal a less reflection from the worse ear, in which cases a primary disease in the labyrinth may be assumed with great certainity.

Tuning-fork Vibrating on a Parietal Protuberance in a Normal Case.—If a vibrating tuning-fork be placed on either parietal protuberance of a person with normal hearing, it will be heard in the opposite ear. This is most easily perceived when a large and powerful tuning-fork of deep note is used. This phenomenon, if it may be so termed, will often lead to confusion in diagnosis, inasmuch as the examiner would expect the fork to be heard best in the ear nearest to which the fork is placed. As it is heard best in the more distant organ, a conclusion might be made that the latter is diseased in its conducting parts.

Care must, therefore, be taken to have the vibrating instrument in the central line of the head, either on the vertex or glabella, or held in or on the teeth. This may be due to the fact that vibrations which fall perpendicularly on the membrana tympani produce the strongest vibrations, and hence a tuning-fork placed on the parietal protuberance, or on the side of the head, will be heard chiefly in the opposite ear. This is very distinctly perceived if both meatus are stopped, but it is equally perceptible, as any one can find out by experimenting upon himself, with the meatus open.

The tuning-fork finds its greatest usefulness in testing by bone-conduction. While it has never fully realized in this way all that was hoped for it as an aid in diagnosis, it is still the best means, and a very good one, too, of determining how much sound is perceived by the auditory nerve, through the bones of the head. Its musical nature, as well as its powerful vibrations, renders it far superior to the watch as a test for the conducting power of the bones of the head, unless the ticking of the watch be made to occur with great force. But should the ticking of the watch equal in intensity the vibrations of the tuning-fork, the former could never approach the latter in musicalness.

The tuning-fork is a means of comparison between bone-conduction and aerial conduction of sound, in the same person. For, if the vibrating tuning-fork be held on the vertex until its note is no longer perceived by the examined, and then held before his ear, if he now perceive that the tuning-fork is still vibrating, it is fair to conclude that the sound-conducting apparatus is normal. But, if the fork, when no longer heard through the air beside the ear, be heard without being restruck as soon as it touches the vertex, the conclusion is inevitable that there is some impediment in the sound-conducting part of the ear. This is all the more convincing if it be borne in mind that there is being used the same note, and one, too, growing a little weaker all the time. For, if vibrations of a tuning-fork cease to be heard in front of an ear, by aerial conduction, but are able to communicate themselves while growing constantly weaker, through the bones of the head, the inference of great derangement in the middle or external ear—the aerial sound-conducting parts—cannot be avoided.

Speech.—By hearing speech the intellectual development of the human being is accomplished. There is no sound so familiar and none for which all so fondly long at times, as that of our native tongue. One with good hearing can never realize the feelings of a deaf person so vividly as when travelling in a strange land, surrounded by people speaking with one another happily, gayly, and with varying expressions, but in a language unknown to the lonely traveller. Such a one falls into the position of an invalid, is treated with a kind of pity, and alas, finds himself growing a little suspicious and morose. The deaf person feels the loss of hearing the voice of others more than the loss of power to hear anything else. To recover the ability to hear the familiar tones of his friends' voices he would gladly give up all other hearing. So great is this struggle to hear what others say, that the deaf gradually learn to understand the words of others by watching their lips. The power to hear other sounds well, may begin to fail without the knowledge of the patient, but all his endeavors are concentrated almost unconsciously to catch the varying sounds of speech.

I have known young physicians to be almost deaf to the ticking of a watch without knowing their loss, for their ability to hear speech was good. All aurists are aware that patients are constantly surprised to learn the amount of their deafness as soon as the face is averted from the speaker.

The failure in hearing in this respect is often first detected by the patient in the summer-time, when all are accustomed to sit on porches or in the parlor, in twilight and the dark. As the daylight fades and the faces of those around are no longer plainly visible, the hitherto apparently hearing person becomes aware that he is growing deaf. This is often assigned to the night air, but in reality it is due to the loss of vision in the darkness. The surgeon will often gain great aid by a knowledge of these facts, and also by observing how a partially deaf patient will look at the person addressed.

Those of delicate sensibility soonest become aware of their defective ability to hear the voice, for speech is not only a delicate sound, but it is highly valued by the cultured as a means of social intercourse. Those of less sensibility are not aware of their loss of hearing for speech, for they still hear loud sounds, and even music so called, for the latter is comparatively much more powerful than the tones of speech.

The value of speech as a qualitative test for hearing has been shown by Donders, Helmholtz, and O. Wolf. But why it was that a patient could hear some words much better than others, though spoken at the same distance, was not explained and applied until Dr. Wolf, of Frankfurt-on-the Main, published his investigations respecting the acoustic characters of the various elements of speech.[1]

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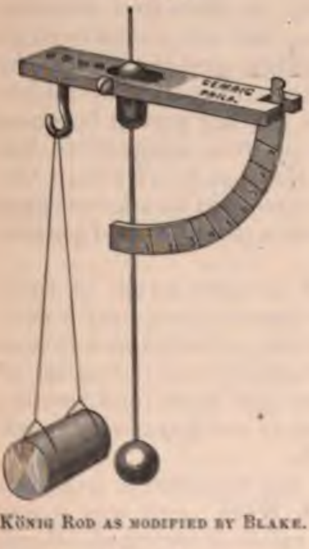
[1] Sprache und Ohr., 1871.

The human ear perceives, as music, tones varying from 16 vibrations to 20,000 vibrations in a second. Preyer[1] has lately placed these limits from 15 vibrations to 40,960 vibrations in a second. Blake[2] has shown that the human ear, in some instances, distinctly hears, as musical tones, 35,000 to 40,960 vibrations in a second.

Speech, according to Wolf, embraces only eight octaves, viz.: R. of 16 vibrations, and S. of 4324 vibrations in a second. It may be said, therefore, to lie entirely within the limits of music.

Perception of High Musical Tones.—With the view of ascertaining the power of the ear to perceive high musical tones, Dr. Blake[3] has performed a series of most valuable experiments with König's rods. The latter are steel rods devised by Mr. König, of Paris, for making accurate acoustic tests with notes of highest pitch.

Fig. 72.



König Rod as modified by Blake.

In order to get a clear tone, it is necessary to suspend the rods by means of loops of silk, or fine wire. To obtain the points at which the threads should be attached to the steel rods, the length of the rod should be divided by 4.3. Thus, if the length is 70.5, this divided by 4.3 = 16.4. The latter would be the distance from each end, at which the loop of the suspending thread should pass round the rod. Then Dr. Blake suggests that in order to obtain a determined intensity of tone, a small steel pendulum, swinging through an arc of 90°, be suspended to the same beam as the steel rod. If the pendulum is made to swing over the arc on which a graduated scale may be placed, the intensity of the blow can always be known and reproduced exactly, if necessary. With this instrument, Dr. Blake has found that the perceptive power of hearing high musical tones varies with the age. At about the age of 12 or 13 years, a tone of 40,960 *vibrations per second* was heard 34 feet; at the ages of 18 to 20 years, the same tone was heard at distances of only 13 to 16 feet, while at 34 feet only the tone of 36,864 vs. was heard. At the ages of from 28 to 30 years, only tones of 32,768 vs. were perceptible, while above the age of 50 years the limit of perception, at the same distance, had still further diminished, and in a greater variety of degree. Dr. Blake's further investigations showed that these changes in perceptive power were due to thickening of the membrana tympani, the latter causing diminution of the power to hear the high tones. An apparent exception occurs, where in addition to thickening, especially in the young, the membrana tympani is drawn in. The increased tension of the latter condition makes the membrana tympani more sensitive to high tones, and thus the thickening of the membrane is somewhat counterbalanced. In two cases of voluntary contraction of the tensor tympani, the perception increased from 3000 vs. to 5000 vs., during the contraction of the muscle, above the limit of perception observed when the muscle was not contracted.

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[1] Jena, 1876.

[2] Transactions American Otological Soc., 1872–3.

[3] Summary of results of experiments on the perception of high musical tones. Trans. Amer. Otol. Soc., 1872.

Further experiments of Dr. Blake showed that when the membrana tympani is perforated, especially at the posterior and superior periphery, the ear can perceive higher notes than when the membrane is intact. This was found to be the case both when perforations had been made by disease, and after artificial perforations.

In one instance, after Politzer's eyelet had been inserted into a thickened drum-head, a steel rod, with a tone of 80,000 vs., was distinctly heard 3 inches from the ear.

In a later paper Dr. Blake[1] bases the claims of high musical tones, to value in diagnosis, upon the following facts: "That the limit of perceptive power of the cochlea exceeds the limits of sound-transmitting power of the structures of the middle ear in their normal condition; that the structures of the middle ear in their normal condition, therefore, present a barrier, as it were, to the passage of sonorous vibrations above a given point; and that the perceptive power of the internal ear remaining the same, morbid changes in the middle ear result in a variation in the limit of their transmission of musical tones." This variation may be either above or below a certain standard point; this point, as already stated, was found to be about 40,000 vs.

When the membrana tympani is perforated the ear may perceive musical tones of 100,000 vs.; the difference between this tone and the tone given as the normal standard may be regarded "as the measure of the degree of resistance, so to speak, which the structures of the normal middle ear present to the passage of the short sound-waves of the higher musical tones."

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[1] Diagnostic value of high musical tones. Transactions American Otol. Soc., vol. i. p. 438, 1873.

Acoustic Character of Vowels and Consonants.—The distance at which separate *vowels* can be heard has not yet been established, but they are endowed with the greatest strength of tone, being heard and understood at a distance at which all the consonants are inaudible. The intensities of vowels given here are such as are obtainable when words containing the given vowels are uttered. The consonants differ very greatly from each other in strength of tone, as will be shown further on.

Vowel-sounds are composed of a number of beautifully harmonic over-tones, which accompany the fundamental note and strengthen that of the mouth. A good musician can hear a perfect accord when a vowel sound, especially A, is uttered with clearness, which is said by Wolf and Appunn to be most observable when the sound is made in the open air, where the sound-waves escape with greater precision than in a room. Dr. Wolf has shown that the broad sound of A has the most overtones, five in all, and is heard the furthest, 360 paces. The sound of Oo has the fewest over-tones, three in all, and is heard with the most difficulty of all the vowels. It can be heard distinctly 280 paces. The vowel O, containing many beautiful harmonic over-tones, is heard nearly as far as the broad A.

The German E, about equivalent to the English A, is heard 330 paces, and the English E is heard 300 paces. The English I is somewhat more powerful (340 paces) than A, but weaker than the broad A or the O sound. Oi is nearly equal to E. Weakest of all diphthongs is Ou, as in out; it is a little stronger than Oo.

Consonants.—Consonants may be classified, according to their acoustic and physiological laws, under two heads, viz., those which are self-sounding, and those which are sound-borrowing.[1] The former are such as possess a sound entirely independent of association with a vowel sound, and one that can be defined respecting its pitch, intensity, and timbre. The latter are such as must be either preceded or followed by a vowel in order to render them audible, and hence the name of sound-borrowing consonants has been applied to them by Dr. Wolf, of Frankfurt-on-the-Main.

H is the weakest of all consonants when pronounced without a vowel. It is lost at the distance of a few paces. Next in strength is B, *Ba* being heard further than *Ha*. B alone is heard at a distance of 18 paces. The deeper a note is, the less effect it has upon the ear. The high notes are the most valuable in this respect, as shown by Moos. R, with only 16 vibrations in a second, is not distinguishable further than 41 paces. K and T stand next; they are both heard equally well at 63 paces. T resembles pretty closely a simple note, but it has a pitch which appeals more readily to the ear, and is, therefore, heard much better than B, which is otherwise very similar to it. K is formed with relatively favorable circumstances, by means of a powerful movement of the root of the tongue. The soft F is heard somewhat further than the foregoing letters, *i. e.*, 67 paces. S is perceived at a relatively greater distance than the foregoing, on account of the pitch of its fundamental note, which by its sharp character attracts the ear.

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[1] "Selbsttönende" and "Tonborgende," Wolf; Sprache und Ohr., pp. 14, 15.

"To its properties as a sibilant consonant it owes its ability to express disapprobation in public assemblies, to cry down opposing sentiments, and to enforce silence. Both its moral and physical character are inharmonic." S can be heard very distinctly 170 paces. Sch German, nearly equal to Sh English, is heard furthest of all consonants, because it possesses full and rich clang-tint, and is composed of three harmonic notes which predominate, while the inharmonic over-tones recede; this composite consonant can be heard 200 paces. M and N, unaccompanied by vowels, are only meaningless blowing of air through the nostrils. Mama and Nana are understood 180 paces, but at a greater distance the sounds of M and N are lost, while the vowel A is still heard.[1]

Helmholtz has also pointed out the very noticeable fact that if in calm weather an observer be placed on some elevation near a town—a tower or a hill-top—it will be found that words are no longer distinguishable, or at best only those composed of M and N with vowels. Vowels can be heard following one another in a curious interchange, and with remarkable cadences, because no consonants are heard, and the other vocal sounds cannot be joined into words.[2]

It is thus shown that in the component sounds of speech a wide range of tests of different intensities and pitch is offered to the aurist. Such a numerous set of tests is needed in order to discover which sounds are heard best by an affected ear. One sound is not sufficient, because an ear may be unable to hear certain sounds, but be comparatively good for others. Hence, if only one or two sounds should be employed, as in the watch, just those sounds might not be heard as well as others. No sound-unit has ever been established, and, if it were, it would be useless, since, from the nature of the ear, such a unit would not be equally applicable in all cases. Therefore, speech becomes valuable as a test because of its composite sound-nature, and, also, because it is ever at the command of the examiner, whose object in applying it as a test is comprehended by the patient without any preliminary instruction.

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[1] Wolf, op. cit., p. 63.

[2] Tonempfindungen, etc., p. 118

Test-sentences and Test-words.—Test-sentences containing long vowel sounds are of great value in testing the hearing. Thus, arbitrary sentences, meaning nothing in themselves, may be chosen for tests.[1] The following are examples: "Pour oil on the waters of Lake Erie," and "He lies here in awe of these four large tigers." Instead of sentences, most aurists use isolated test-words, for the sake of convenience. These may be chosen according to their logographic value. Blake[2] demonstrates that a comparison of a large number of logographic tracings of the force-values of consonants shows that, while the force-value of the consonant sounds differs largely in different individuals, and differs also in the same individual at different times, the comparative value of the consonant sounds one to another bears a fairly, though by no means absolutely, definite ratio. If, therefore, we take the consonant sound which requires the greatest logographic value, and which would be most readily heard, expressing its value as 100, and that of other consonant sounds accordingly, we have a table from which to select materials for a list of test-words, based upon intensity rather than upon pitch of the voice-force producing them, and serving, as in case of chronic catarrh of the middle ear, as a measure of obstruction to the passage of sound. In compounding words from this table, it is better to use monosyllables, and it should be kept in mind that the logographic value of consonants formed at the back of the mouth is greater in combination with the lower-pitched, and of the front consonants in combination with the higher-pitched, vowel sounds. The tabular list is as follows: T 100, B 53, P 58, D 45, G 56, S 40, Z 53, C 62, F 35, K 31, L 21, N 11, M 9.

Whispering and Loud Tones.—Very often whispers and words spoken in low tones are heard much more distinctly by the affected ear than loudly spoken words. This is due to the damping of vowels, as shown by Wolf, whereby the consonants, which have been stated to be less sonorous than vowels, have a chance to be heard. This fact is of great importance, not only in estimating the hearing, but in addressing those hard of hearing. Members of a family very often pitch their voices too high, and hence confuse the afflicted one, thus gaining the idea that the individual is deafer than he really is. On the other hand, they are surprised that on some occasions he hears sounds and words spoken to others in comparatively low tones. So marked is this in those hard of hearing, that it has been said a deaf person always hears when it is especially desired that he should not. This is due to the physiological acoustic fact mentioned above, that in low-spoken tones the vowels are quelled, and the consonants, being allowed thereby a better utterance, are relatively strengthened, and the whole word is heard better than if roared out. This damping of vowels has both its good and bad side. Do not elevate the voice too high when you wish to make a deaf person hear, but do not lower it too much, unless to a whisper, if it is not desired that he should hear.

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[1] Dr. A. H. Buck, American Otol. Society, 1876.

[2] Transactions of American Otol. Society, 1881.

Words may be heard even when the letters composing them, spoken separately, are not heard. This is especially so for the letters B, P, T, K, and R. The reason of this lies in the fact that letters pronounced alone are really words. Thus B is really composed of sounds of *b* and *e*, as in *be;* P, of *pea* or *pee;* K, of *kay*, while R is equivalent to sounds of the word *are*. It may be said very truly that, in the latter instance, R, when pronounced alone, is altogether of a phonetic value different from that when standing at the beginning of a word, as in *Rab*, or at the end of a word, as in *Tar*.

Whispering.—Whispering has an advantage over loud words in testing, since the former cannot be as easily conveyed as the latter through the bones of the head to the auditory nerve. However, it must be borne in mind that in a case reported by Dr. Dennert,[1] in which the cochlea had been lost by necrosis, the *normal* ear, though artificially stopped up as thoroughly as possible, could yet hear whispers six feet off. Sometimes, patients hear music better than speech, because the faintest music of an orchestra is more powerful than speech, as stated by Wolf.

Variable Hearing.—The hearing varies very greatly in cases of movable fluid in the tympanic cavity and in some forms of aural vertigo. When such peculiarities of hearing are fully established, they may aid greatly in diagnosis. The first kind is made manifest by changes of position of the patient's head; the second form of variability of hearing comes and goes with the paroxysm of vertigo. It is probably due to alterations in the condition of the muscles in the tympanum, whereby altered tension in the sound-conducting apparatus is produced.

Hearing Low Tones better than High Ones.—It is sometimes observed by patients that they hear low, bass notes much better than high ones; as, for example, in two instances, patients volunteered the information that they heard thunder much better than the chirping of crickets, and bass notes much better than high ones on the piano or organ. In testing with a watch, it was found that one giving out the deeper note was most easily heard by one of these patients; the other was not thus tested. Experimentally, I have shown that a deep note has the advantage of high notes in cases of increased labyrinthine pressure (p. 96). In an increase of such pressure, the stapes becomes more fixed, and it is on this small bone that the vibrations begin to grow less as the pressure within the labyrinth is increased. In such a case, it is manifest that, if vibrations from without are normally conveyed to the stapes, there they must meet with hinderance in their endeavor to reach the labyrinth. Only the more powerful sound-waves are able to overcome this obstacle and force the stapes into to-and-fro motions with the rest of the chain of ossicles. I have, therefore, thought it might be asked, Could not the inability to hear high notes in some cases, while low ones are heard nearly, if not quite normally, be construed into a sign that the stapes is impeded, either by undue pressure in the labyrinth, or by catarrhal fixation in the oval window? That the cause of such a peculiar alteration in hearing probably does not lie in an undue tension in the membrana tympani, appears from the well-known physical fact that the tense membrane is more susceptible to vibrations of high notes than to those of the low.

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[1] Archiv f. Ohrenh., Bd. x.

The Position and Extent of Perforation in the Membrana Tympani may cause variation in the hearing power for certain sounds, especially consonants, as shown by Wolf.[1] Experiments with the consonant B upon defective drum-heads show that the perceptive power for this sound diminishes as the extent of the defect increases. The faintness of the consonant is most observable when it stands at the end of the word. It may also be said that defects of the membrana flaccida are attended with great deafness for all sounds, which is probably due to an implication of the malleo-incudal joint.

Testing the Hearing in One-sided Deafness.—In measuring the hearing for sounds conveyed through the air in cases of one-sided deafness, or of hardness of hearing confined chiefly, if not entirely, to one ear, care must be taken not to attribute to the worse ear that which is really heard by the better ear, though stopped and turned from the examiner. In any case where one ear is being tested, accuracy would demand the isolation of the other. Usually, the ear not being tested is stopped and turned from the source of sound, the ear under examination being left open and turned towards the sound-source. This method will usually give at least a proximate result as to the amount of hearing in the worse ear, but in order to exclude the fact that the better ear, though stopped and turned away, hears some of the test, it will be necessary to measure the hearing in the worse ear alternately open and stopped in order to see what effect this stoppage will have upon the amount of hearing it is supposed the worse ear still retains.

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[1] Sprache und Ohr., 2d part.

In the method of Dennert and Lucæ,[1] the voice is relied upon chiefly for the test. The *better* ear is stopped, turned towards the source of sound, and tested, the deafer ear being alternately opened and closed. The difference in the hearing, if there be any elicited by this method, is set down to the worse ear.

A plan similar to the foregoing, and one which I have used for a long time in cases of one-sided deafness, is as follows: Place the patient so that the affected ear is towards the surgeon. Then with the finger stop the ear not to be tested. This may be done by the patient or by an assistant, preferably by the latter when great certainty is needed. Now, with the affected ear open and turned towards the surgeon, let tests of its hearing power be made. When the apparent limit of hearing on the affected side is obtained, let that ear be closed as the other ear is, and then, with the affected ear still turned towards the examiner, let tests be made again. If the closure of the deaf ear causes no difference in the hearing distance already obtained, it is fair to conclude that whatever amount of hearing exists is not due to passage of sound through the external auditory canal of the worse ear turned towards the test. In such a case the conclusion must therefore be, that sound either goes more easily through the bones of the head on the affected side than through the meatus, to the auditory nerve (which would be absurd), or that sound has reached the brain by the other ear. Also, it may be concluded that the affected ear is practically, totally deaf.

If, however, stopping the ear turned toward the examiner (the ear supposed to be the deafer) makes that ear still deafer, let the examiner approach the patient and repeat the tests until they are heard once more. The second hearing of the tests is evidently due to conduction of sound through the cranial bones and the finger in the meatus, and, therefore, must not be mistakenly regarded as aerial conduction. The extent of the power of the ear to hear in this latter way will be expressed in the difference between the limit of hearing the first test and the limit of the second. Thus, a patient may hear speech as far as eight feet, with the good ear stopped and turned away, and the affected ear open. When the latter is stopped, but still turned toward the examiner, speech is no longer heard at eight feet, but it may be perceived by the patient at a distance of three feet, both ears still being kept firmly stopped. In such a case, not the former distance, but the difference between it and the latter distance, viz., *five* feet, must be regarded as the limit of aerial conduction by the external auditory canal, for that represents the *amount of loss of hearing caused by stopping the meatus.*

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[1] Archiv f. Ohrenheilkunde, 1875.

Whatever is heard just as well with the deafer ear stopped as when open, the better ear remaining stopped throughout the testing, must still be heard by the better ear through the head; but whatever is heard only with the worse ear open, the good ear being stopped, must be attributed to the worse ear.

Another method of getting at the amount of hearing in a very deaf ear, or perhaps a totally deaf one for all that is known before the examination, is to begin the testing with both ears of the patient closed. Then, with the worse ear toward the sound-source, try to find out how much is heard; after which let the artificial stoppage, usually accomplished either by the finger of the patient or of an assistant, be removed from the worse ear, the better one remaining stopped.

The difference in the two results, if there is any, must be the true amount of hearing on the affected side. If there is no difference in the result, it is fair to conclude that sound conducted through the auditory canal to the deaf ear is not perceived by it. This being the case, if words repeated on the affected side are still heard, it is not due to any remnant of hearing power in the deaf ear, but rather to the passage of sound through the head to the good ear.

The question might be asked, Why cannot sound be conveyed to the deaf ear through the head, if it is conveyed to the better ear, which is stopped and turned away from the sound-source? The reply would be, that an ear which, either when stopped or open, perceives no difference in sound conveyed by the meatus, is not sensitive enough to hear sound conveyed to it through the head.

The Entotic, Application of the Ear-trumpet.—In order to find out which parts of the chain of ossicles are most affected in cases of sclerosis and stiffening of these portions of the middle ear, it has been proposed by Dr. Albert Bing,[1] of Vienna, to substitute the ordinary means of diagnosis found in the catheter, the auscultation-tube, and in the direct inspection of the membrana tympani, by what he terms the entotic application of the hearing trumpet.

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[1] Die entotische Anwendung des Hörrohrs. Monatsschr. f. Ohrenheilkunde, Nos. 8, 9, and 10, 1876.

This is done by speaking through a collector of sound, one end of which is made to communicate directly with the tympanic cavity, through a catheter fixed in the Eustachian tube. By such an apparatus, sound-waves may be brought directly into the tympanum and made to fall immediately upon the foot-plate of the stapes, from which they are carried over to the fluid of the labyrinth and the auditory nerve. During the examination by this method, the ears of the patient are to be stopped, in order to prevent sound from entering by the external auditory canals, and, in order to prevent lip-reading, the eyes of the patient should be closed; he may then be required to repeat what he hears.

According to the greater or less ability of the patient to hear by this method, Dr. Bing concludes that, 1, the stapes is entirely normal, or 2, that it is more easily movable than either of the other ossicles; 3, that the obstacle to conduction lies only in the stapes or in it and the other ossicles at the same time, or 4, that the stapes has become anchylosed. In one instance in which the patient heard much better by the entotic method, until a perforation in the drum-head was freed of tough exudation, when he heard better both with and without the trumpet, it was concluded that the chief obstacle to conduction of sound lay in the malleus and incus, while the stapes was easily moved.

SECTION II.

AURICLE.

CHAPTER I.

ORGANIC DEFECTS AND CUTANEOUS DISEASES.

ORGANIC DEFECTS.

Among organic defects in the auricle may be mentioned, absence, plurality, abnormal position and shape, as well as partial and defective development.

A partial or total want of the auricle may be congenital. This may be confined to one side, or it may occur on both sides and in conjunction with other defects of the head produced by alteration or imperfect development of the visceral arches. Such defects interfere more or less with the fineness of hearing. Traumatic loss of the auricle frequently occurs from accident, punishment, and disease.

Plurality and Abnormal Position of Auricles.—A plurality of auricles has been found in lower animals[1] and in man. "Cassebohm relates a case of a child with four ears, two naturally placed, and two lower down on the neck; there were in this instance two petrous portions in each temporal bone."[2]

Birkett[3] has reported the case of a young girl who, in addition to irregularities in her ears, had on each side above the middle of the sterno-cleido-mastoid muscle, a large growth resembling the lobule of an auricle, each supplied with an artery, and containing reticular cartilage like that of the pinna.

Fig. 78 represents portions of a supernumerary auricle which I observed in a woman, forty years old, who presented herself at the Philadelphia Polyclinic. There appeared to be a rudimentary and supernumerary tragus and lobule. Her auricles were normal, and her hearing unaffected.

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[1] Especially in the pig; Wilde, op. cit., 161.

[2] Wilde, op. cit., p. 161.

[3] Transactions of Path. Soc., London, 1858, vol. ix, p. 448.

Fig. 74 represents a supernumerary tragus in front of the auricle of a boy eleven years old. The hearing was perfect.

Fig. 73.

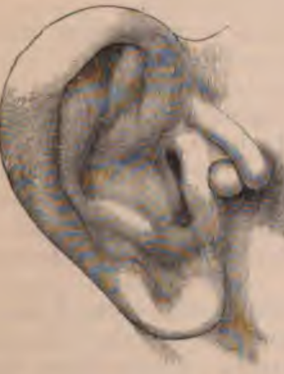
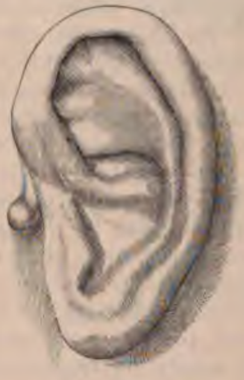


Fig. 74.



The lad having applied for relief from an attack of herpes zoster on the helix and antihelix, the appendage was seen and sketched.

Malformations of the Auricle.—Malformations of the auricle are generally found connected with defects or absence of the external auditory canal. The surgeon is usually consulted to know whether the malformation will interfere with the hearing of infants thus deformed, and, if so, whether an operation will relieve the deafness and deformity.

Mr. Toynbee,[1] in his excellent work, has given an account of a paper by Prof. Allen Thomson,[2] treating of malformation of the external ear and the condition of the hearing in such cases. It is there shown that in an incomplete development of the integumental part of the apparatus, viz., the auricle and outer part of the meatus, there is usually absence of the tympanic ring, and consequently of the bony part of the meatus; that there is also a defective state of the cavity of the tympanum and chain of small bones, and occasional irregularity or deficiency in the development of the malar, palatal, and maxillary portions of the face and mouth.

Gruber[3] has stated that in deformities of such a high grade he has never found a normal auditory canal. Usually there is not a trace of one present, or at best it is a narrow and short blind passage connected with the auricle. The latter usually does not occupy a position similar to that of a normal auricle, but is either nearer the cheek or pushed downwards toward the throat, and is movable in all directions with the neighboring skin. This is an important fact to bear in mind, if there is any inclination to make an artificial auditory canal.

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[1] Diseases of the Ear, London, 1868, pp. 14, 15.

[2] Edinburgh Journal of Medical Science, April, 1847.

[3] Lehrbuch der Ohrenheilkunde, p. 275.

Of the two cases reported by Dr. C. J. Blake,[1] the following is considered by him as of great interest:

It occurred in the right ear of a girl three years old; the long diameter of the auricle formed an angle of 45° with the vertical plane of the head; the position of the helix was barely indicated by a slight reduplication of the superior portion of the auricle, and the antihelix represented by a slight elevation above the superior border of the concha; the whole of this portion of the auricle resembled that of the chimpanzee, or of the cases of dementia given by Laycock.

"The perception for musical tones on this side of the head seemed to be good, and the integument covering the meatus could easily be depressed with a probe. Under these circumstances, an exploratory operation was advised, but unfortunately the patient did not return at the appointed time. The family history of the patient gave no other case of malformation, and the little patient herself was otherwise normally developed."

Fig. 75.

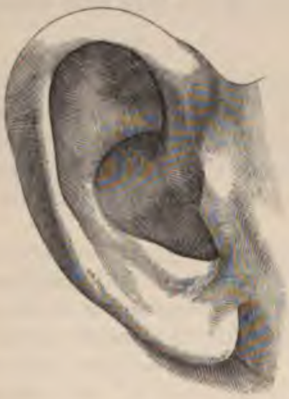
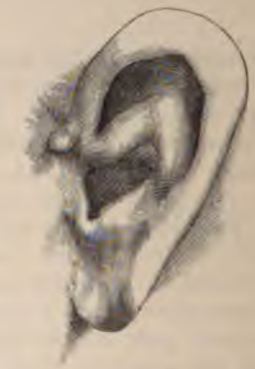


Fig. 76.



The accompanying figures represent the ears of a boy eight years old, the left auricle of whom is small and deformed. I saw this case when he was only three years old. The deformities are congenital. In January, 1884, when he was eight years old, I examined him again, and made the following notes. The hearing of the right ear is perfect. The tuning-fork vibrating on the vertex is best heard in the right ear. There is no meatus on the left side, but there is a slight depression on the concha where usually the meatus is found. The auricle seems loosely attached to the side of the head, and the finger cannot detect anything like an osseous canal. The auricle seems to be attached to a cup-shaped depression lying between the mastoid and the root of the zygoma. The child is otherwise healthy, as are his parents and brothers and sisters. There are no supposed reasons given by the parents for the deformity in their child.

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[1] Statistical Report, 1652 cases of Diseases of the Ear. Mass. Charitable Eye and Ear Infirmary, 1872.

With rudimentary auricles and absence of external auditory canal sometimes there may be found a faulty development of the corresponding side of the face, as observed by von Troeltsch and Wagenhäuser.[1] Cases of microtia have been reported by Blake and D. Hunt,[2] and also by W. H. Robb.[3] In connection with congenital macrostoma, in which a fissure-like prolongation of one side of the mouth is found extending into the cheek backwards toward the ear, and in which the lower jaw is malformed, malformations of the auricle and auricular appendages are observed.[4] In these cases the hearing may not be much, if at all, affected.

Congenital Fistula of the Ear.—This is a rare form of malformation or arrested development near the ear. Cases of it have been described by Schwartze, Heusinger, Schede, Schmitz,[5] and Pflüger.[6]

It consists in a dimple or a small fistulous opening close in front of the tragus, in the helix, or just in front of it, above the tragus, and in the concha, which may extend in some cases as far as the tympanic cavity. It may be symmetrical, as shown by Pflüger, or in connection with defects in the throat, as shown by Schmitz. In the case given by Pflüger a probe could be inserted 1½ cm. without difficulty or pain. An interesting fact connected with the history of this case was that pus had been discharged a number of times from these openings, after attacks of earache. The cause of this anomaly is considered by Heusinger, Schmitz, and Pflüger to be an arrest of development in the first visceral cleft, a view also held by Virchow. Urbantschitsch[1] reports twelve cases of this defect occurring among 2000 cases of ear disease, observed by him in Vienna. It was bilateral in three instances. The same writer states that this defect is more common in the lower animals, like the sheep and the horse, than in man, as has been shown by Meckel and Geoffrey St. Hilaire. Kipp, Schwabach, and Paget have also published accounts of the observation of this defect. The author has seen six cases of it.

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[1] Archiv f. Ohrenheilk., Bd. xix. S. 55.

[2] American Journal of Otology, vol. iii., 1881, p. 3.

[3] Ibid. p. 278.

[4] John H. Morgan, British Med. Journal, Nov. 12, 1881.

[5] Ueber fistula auris congenita, etc., Halle, 1873. A. f. O., Bd. ii., N. F. 1874, S. 301. Abstract by Jacoby.

[6] Monatsschr f. Ohrenheilkunde, No. 11, 1874.

CUTANEOUS DISEASES OF THE AURICLE.

There are some cutaneous diseases of the auricle and of the parts adjacent to the ear which may fall to the care of an aural surgeon, and they shall be briefly considered.

Simple Erythema.—This disease is usually caused by local irritation from bites of insects, badly fitting head-coverings, especially in infants, the action of the sun on the exposed ear, and the instillation of various nostra into the ear, or by irritating discharges from the organ itself. The membrana tympani may not be affected.

Treatment.—In mild cases of erythema of the auricle very little treatment is demanded. If the itching and burning are great, it is best to use soothing dressings, such as cream, ung. aquæ rosæ, simple cerate, and the various mucilages, an excellent one being quince-seed mucilage.

Erysipelas.—Erysipelas of the auricle may occur as a primary or idiopathic disease from local cold, or secondarily by extension of the disease to the auricle from parts adjacent to it. In the latter instance the prognosis will depend greatly upon the condition of the patient and the previous condition of the ear.

While erysipelas of the face and head as a rule will render hearing in any case dull, most probably by an occlusion of the auditory canal, it does not necessarily leave the hearing permanently impaired. Even where erysipelas attacks an ear previously diseased, the bad consequences are not permanent. In the case of a young lady, 18 years old, I have seen four or five attacks of erysipelas of the face in the course of a few years. On the right side she has a chronic purulent discharge from the ear, dating from early childhood. During the time she has been under my observation the erysipelas has always made the condition of the diseased ear temporarily worse, but notwithstanding the repeated hinderances to recovery, experienced by the ear, it has gradually assumed a more healthy condition.

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[1] M. f. Ohrenheilkunde, No. 7, 1877.

Treatment.—The treatment of erysipelas of the auricle is similar to that of the disease elsewhere, excepting that care must be exercised not to apply such cold dressings to the ear as would be justifiable in the disease on the face. It is preferable to apply light dressings to the erysipelatous ear, such as light gauze or linen sprinkled with flour or rice powder, and to *avoid cold moisture.*

Intertrigo.—This disease may be found in children of all classes, and in the healthy as well as the unhealthy. It is caused by mechanical irritation where the posterior surface of the auricle comes in contact with the mastoid surface. It is due primarily to a certain amount of maceration of these surfaces, which favors excoriation and chafing. Hence dryness behind the auricle must be maintained. Cleanliness, of course, must be observed, but too much washing is as bad as too little. The disease may also be caused by too much warmth about the head, tightly fitting caps, picking at the ear on the part of the children themselves, or by tossing or working the head about on the pillow, which, of course, causes the auricle to rub against the mastoid surface. The prognosis is favorable. The disease should be arrested as soon as possible in order to prevent it from passing into an eczematous condition.

Treatment.—After the disease is fully established all washing of the parts behind the ear should cease, and the moist surfaces be dusted with a powder consisting of one part of oxide of zinc (Hubbuc's preferable) and from two to seven parts of pure starch. This will form a white crust, which should be let alone until it drops off, when the surface underneath will be found to have entirely healed.

Frost-bite.—In very cold winters with us, and in cold climates every winter, frost-bitten ears are not uncommon. No special treatment is demanded in acute cases. Care must be taken to avoid too sudden a reaction, and this is done by the application of ice-water or snow at first, with the gradual application of warmer water. If vesicles and subsequent excoriation occur, we must prevent the access of air as much as possible to the affected parts, by the application of emollient cerates or collodion.[1] In many cases, when nothing better can be procured, the excoriations, produced by the frost-bites, on the auricle may be covered by linen smeared with ordinary glue.[2] New formations of cartilage may occur throughout the entire helix and the major portion of the pinna, as a result of frost-bite, and hard and sensitive nodules may be felt in the lobe. In such a case, seen recently by the author, the skin was purplish, covered with a slight amount of branny scales, and the nodules could be distinctly seen as well as felt. The nodules in the auricle in this case did not resemble the gouty deposits described by Garrod.[1] They were so close together that the surface of the cartilage of the auricle had lost entirely its smoothness. At the same time, the entire auricle, especially at the more elevated nodules, was quite sensitive to pressure.

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[1] Rau, op. cit., p. 161.

[2] Ibid.

Tophi, as described by authors treating of gout, do not appear to be very common in this country.

Lupus erythematosus, lupus vulgaris, psoriasis, ichthyosis, comedo, acne, keloïd, molluscum fibrosum, with the disease elsewhere on the body, and ringworm, may attack the auricle; but beyond the mere mention of their occurrence, it is not necessary to enter into a discussion or description of them here. The reader is earnestly requested, however, to bear in mind the possibility of these diseases being found on the auricle and concha, and in the auditory canal, and to become acquainted with their nature and treatment as set forth in works on dermatology.

Pemphigus Gangrænosus of the Auricle.—This disease was first described by Dr. Whitley Stokes, and mentioned by Wilde[2] in the medical memoir attached to the census of Ireland in 1841. It is peculiar to Ireland, very apt to attack children on or about the ears, is very fatal, and prevails especially among the lower orders. It is said to have caused 17,799 deaths in ten years in Ireland, the truth of which, Wilde is inclined to believe. It is not known in this country, though the scars left by it have been seen by the author, in an Irish woman.

Phagedæna, or cancrum auris and gangrene from embolism, may be mentioned as of uncommon occurrence.

Gangrene of the ears occurs in some low fevers; it may be symmetrical and associated with gangrene of the nose. It has been observed after intermittent fever by H. Fischer,[3] and after typhus by Estlander.[4] Gangrene of the auricle is similarly referred to by Patry,[5] and by Barker and Cheyne.[6] It is usually a very bad symptom, being the immediate precursor of death in most cases, though recovery has ensued after gangrene of the auricles had occurred in typhus fever, as shown by Estlander, and by Barker and Cheyne. It is generally associated with livid and gangrenous spots elsewhere on the body.

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[1] Treatment of Gout, London, 1859.

[2] Diseases of the Ear, American ed., 1853, p. 174.

[3] Langenbeck's Archiv, vol. xvii. pp. 335–339.

[4] Quoted by Fischer.

[5] Archives Générales, 1863, i. p. 144.

[6] Observations on Fevers, etc., p. 232, vol. i. See also Toner Lecture for 1877, by Wm. W. Keen, M.D.

Eczema.—Eczema, both in the acute and chronic form, may be found in the auricle, and, as a disease modified by its seat in an organ of special sense, becomes of interest to the aurist. The *acute* form is more common than the chronic, attacks all ages and sexes, but is more frequent in children and in females. It is supposed to be connected with the phases of menstruation, and is considered by some, to be, with other symptoms, indicative of the menopause.[1] In children, acute eczema is often produced artificially by uncleanliness, by their own picking at the ear, and by head-coverings which fit too closely. In adults, acute eczema of the ear is frequently caused by the introduction into the organ of improper remedies for earache, toothache, etc.

Acute Eczema of the auricle or auricles may be idiopathic or an accompaniment of other diseases of the ear, or it may occur in the auricle from the contiguity of the latter to other parts of the head affected by the disease. The idiopathic form may appear on *both sides* of the auricle, or it may be circumscribed on the anterior surface. The greatest interest this disease can have for the aurist, is when it attacks the auditory canal and invades the membrana tympani.

Treatment.—The treatment of eczema of the auricle will be similar to that of eczema anywhere else on the general surface, with of course the modification rendered necessary by care not to apply any remedy which, by escaping into the auditory canal, would injure the drum-head. The treatment of the *acute* form of eczema of the auricle should always be very simple, and the dressings, when once applied, should not be changed more than twice daily. Most important is it that little or no washing, and absolutely no soap, should be applied to the auricle affected with acute or even subacute eczema. Both glycerine and cod-liver oil, applied on pledgets of charpie, and bound firmly to the eczematous auricle, are of great value in children.[2]

The following powder will be found of great benefit in cases of acute eczema of the auricle:

℞.—Flor. zinci, ʒij;
Aluminis,
Amyli, āā ℥j.
M. Fiat pulv.

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[1] Gruber, op. cit., p. 288.

[2] Gruber, Lehrbuch d. Ohrenh., 1870, p. 292.

Another, equally useful, is as follows:

℞.—Zinci ox., ʒj–iv;
Amyli, ʒiv–vij.
M. Fiat pulv.

These powders should be dusted carefully and thoroughly over the diseased auricle, and the latter should then remain undisturbed as much as possible. The ointment of the oxide of zinc, benzoated, is also a very efficacious remedy in eczema of the auricle, acting as a protector.

If the heat and burning become very great in acute eczema of the auricle, *cold* must be applied, with caution, to the diseased surface. This is best done with cloths steeped in cold water.

Hebra[1] used, in acute eczema, a salve which he called the Ung. Diachyli, which is made as follows:

℞.—Ol. olivæ, opt. fl℥xv;
Lithargyri, ℥iij ʒvj;
Aquæ, q. s.
Coque. M. Fiat Ung.[2]

This may be used in acute eczema of the auricle. The salve may be rubbed in with the finger two or three times daily, or it may be smeared on linen and the latter applied as a plaster.

Subacute Eczema.—Should the eczema pass, as it is apt to do, into a subacute form, characterized by great swelling, vesicles, and fissures in the skin, the auricle should be thoroughly rubbed twice daily, with sapo viridis, the Schmierseife of the Germans. Then the disease should be treated as an acute form.

The subacute form of eczema of the auricle may be treated beneficially by the application of *acetum cantharidis* to the sluggish parts, and then pencilling the latter with the following:

℞.—Ol. cadini, flʒij;
Alcohol, fl℥j.

This will often prevent the disease from becoming chronic.

Treatment.—In chronic eczema of the auricle, the aim must be to allay irritation, and at the same time to stimulate the parts into a healthy action. Attention must also be paid to the general condition of the patient, and the internal treatment by means of alterative tonics, among which arsenic will be found highly efficacious, will play an important part in the management of the chronic forms of this disease.

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[1] See Gruber's Lehrbuch d. Ohrenheilkunde, p. 294.

[2] This ointment is difficult to make, requiring more than ordinary pharmaceutical skill. That form prepared by McKelway, Borell, Cramer & Small, and J. P. Remington, of Philadelphia, is recommended by Dr. Duhring, ***Diseases of the Skin***, p. 188, which see.

Various kinds of *local* treatment have been proposed for the chronic form of eczema of the auricle, among which, the best are painting the diseased parts with acetum cantharidis, nitrate of silver (gr. x to fl℥j aq.), and the application of emollients, the head being kept dry and cool. It has also been proposed[1] to coat the auricle with a solution of gutta-percha in chloroform, or to apply to it various forms of ointment of zinc and ammoniated mercury (U. S. Pharm.). The ointment made of the latter I have found most useful, as suggested to me by Dr. L. A. Duhring, of Philadelphia, in the following formula:

℞.—Hydrargyri ammoniati, gr. x–xx;
Adipis, ℥j.
M. Fiat unguentum.
S. To be rubbed gently but thoroughly in.

Dr. Duhring[2] places the preparations of tar amongst the most useful remedies, after the acute stages have passed away. The use of solutions of potassa, followed by stimulating ointments, is also highly recommended. Dr. Duhring's experience has been that eczema of the auricles is usually obstinate in its course.

When the eczematous disease has invaded the canal, and stimulation of the parts is needed, an ointment may be used, composed as follows:

℞.—Hydrarg. ammonio-chloridi, ℈j;
Unguenti adipis, ℥j.—M.
S. Apply with a camel's-hair pencil to auditory canal once or twice daily.

Another stimulating ointment is as follows:

℞.—Hydrarg. chlor. mitis, ʒj;;
Ung. zinci oxidi, ℥j.—M.
S. Apply to the external ear thoroughly, twice or thrice daily.

Or the following:

℞.—Hydrarg. ox. flav., gr. viij–xvj;
Vaselini, ℥j.—M.
S. Apply as above to the auricle or canal.

Acute Phlegmon.—Wilde[3] has mentioned a form of simple phlegmon of the auricle caused by the sting of insects, which, however, does not appear to demand treatment. Rau[4] has described an idiopathic form of acute phlegmon of the auricle, which, running a severe course, with systemic derangement, rigors, etc., terminated in suppuration.

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[1] Wilde and Graves. See former, op. cit., p. 173.

[2] Treatise on Diseases of the Skin, pp. 207, 208, 1877.

[3] Diseases of the Ear, Phila., 1853, p. 169.

[4] Ohrenheilkunde, Berlin, 1856, p. 163.

Chronic Phlegmon.—A chronic plegmon of the auricle has been described by some writers as terminating in cancer. It is characterized by a circumscribed hardening at some part of the auricle, usually the tragus or lobule, which gradually spreads, producing hypertrophy and degeneration of the entire auricle, with thickening of the skin, lymphatic exudation, and after years of suppuration the auricle is at last destroyed. In some cases death has supervened as the result of exhaustion from this disease.[1] The auricle may become very large, as shown by Krügelstein,[2] as quoted by Rau, who believes this disease is an insidious form of cellulitis, with secondary sclerosis of the skin, occurring in unhealthy subjects. The description suggests epithelioma.

Treatment.—The treatment must be alterative, and if considerable hardening and hypertrophy of the auricle exist, it may be necessary to amputate, which has been performed successfully by Fischer.[3]

Circumscribed Inflammation of the Cellular Tissue. — Circumscribed inflammation of the cellular tissue of the auricle occurs in the form of boils. In the impoverished system they may become carbuncles, and produce permanent deformity of the pinna.

A chronic attack of boils in the *lobule* has been noted by the author in a medical friend. These have occurred for years, but have rather decreased in frequency since an attack of typhoid fever. There has never been any deformity or loss of substance in the lobule, a rather curious fact when we remember the large amount of suppuration that has occurred from the small affected spot.

The matter discharged from these boils, which usually discharged themselves on the posterior surface of the lobule, had a peculiar odor resembling that of valerian. Habermann[4] observed an abscess on the posterior surface of the auricle which discharged into the auditory canal.

Cornu Cutaneum Auriculæ.—Horny growths are occasionally found upon the human auricle.

Dr. A. H. Buck[5] observed a case of this nature in January,

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[1] See Rau, op. cit., p. 164. Wepfe., Grundriss der Chirurgie Operat, Nürnberg, 1825, p. 118. Conradi, Surg. Experiences, Berlin, 1830.

[2] Ueber den Krebs am Ohr. Allg. Med. Annalen des 19 Jahrhunderts, 1827, pp. 145, 152.

[3] Rau, op. cit., p. 167.

[4] Transactions of Amer. Otolog. Soc., 1871, pp. 18, 19.

[5] Archiv f. Ohrenh., Bd. xvii. S. 29, 1881.

1871; it was a blunted, horn-like protuberance, three-fourths of an inch long, and nearly as broad at its base; it sprang from the upper and posterior part of the left helix. It was whitish in color at its base, but gradually grew quite brownish at its summit, which was more or less jagged in appearance.

It was distinctly striated, the markings running in a slightly divergent direction from the summit to the base. At the extremity and in the middle portion it was hard like horn, but near the base it could be easily compressed, though yet comparatively hard. The line of demarcation between the growth and the normal skin was very abrupt. It was not a source of pain to the patient, nor was there any tenderness on pressure.

The growth was cut off by two incisions along either side of the base, the fresh edges approximated, and the wound dressed with lint. Union took place by granulation, and at the end of the third week scarcely a trace of the operation was visible.

I saw, some time since, in the Philadelphia Infirmary for Diseases of the Ear, a case of horny growth on the upper and outer portion of the helix of the left ear, in a large, strong man, forty-five years old, whose occupation obliged him to expose himself to all kinds of weather on the river. The growth was smaller than that described by Dr. Buck, and was not discolored on its outer edge.

It caused no annoyance, but the patient had begun to pick it, and it was growing larger, when the man disappeared from observation. The middle ear on the same side was affected by a chronic purulent discharge, of slight amount.

Secondary Syphilitic Eruptions.—In a monograph on syphilitic diseases of the ear, Gruber says he has never met with a primary sore in any part of the ear. He has, however, frequently seen secondary eruptions on the various parts of the ear, and has observed that particular portions of the external ear favor certain forms of eruption, as, for example, the point of insertion of the auricle and the lobule is most liable to a papular eruption, while the other parts of the auricle most frequently show an exanthematous eruption. Squamous eruptions, too, are found on the auricle, rather than in the meatus. These diseases of the auricle do not, however, interfere with the hearing to any marked extent, and belong rather to the province of dermatology. Syphilitic ulcers and warts on the auricle, I believe, are rare. They are certainly not often recognized and described.

Tubercular Syphiloderm.—An infiltration of the syphilitic materies may be diffused throughout the skin of the auricle, or it may occur in the form of tubercles, varying in size from that of a split pea to that of a cherry. The latter may coalesce, and thus form a general infiltration. The posterior part of the auricle is more likely to be attacked first than any other point, the spot most liable being the point of junction between the auricle and the head. This disease manifests itself any time after the first year of the inoculation has passed. It is most apt to occur in from two to ten years after the primary sore. I have recently observed a case of this disease of the auricle under the care of Dr. L. A. Duhring. In this instance, there first appeared a circumscribed, infiltrated lump on the posterior surface of the auricle, which gradually increased, until it has diffused itself throughout the tissues of the pinna. It was slightly elevated above the general surface of the auricle, of a deep reddish color, painless, and there was no itching in the growth; the latter was inclined to run a slow course. In the space of a month or six weeks, the infiltration had diffused itself throughout the greater part of the auricle, and somewhat over the mastoid portion. The thickening and deformity of the auricle had become considerable, the groove behind the auricle was obliterated, and the appendages assumed a firm, thick feeling. This condition lasts for some weeks; then softening and ulceration ensue, the latter beginning in some natural groove or depression. The ulcer varies in size, shape, and depth, its base is reddish, and covered with a yellowish or grayish puriform matter. The rate of ulceration varies according to the general condition of the patient; the auricle may be destroyed in the course of a few months. There is still no pain, the discharge is more or less offensive, usually the latter to a marked degree.

Dr. Samuel Sexton[1] reports three cases of tubercular syphilide of the auricle. He regards this affection as a tertiary lesion met with late in syphilis, and states that it is not liable to ulcerate, and that the loss of tissue when present is due to interstitial absorption. His experience leads him to the conclusion that the disease is disposed to confine itself to the anterior portion of the pinna.

In an account of thirty cases of syphilitic disease of the organ of hearing, Dr. A. H. Buck[2] states that he found only two cases of syphilitic ulceration of the auricle. Both patients were men; the ulceration occurred within, or partly within, the fossa helicis. The ulceration in one case was deep; in the other less so. The tragus was swollen in one instance. Syphilitic ulcerating gumma of the auricle has been described by Hessler[3] as a tertiary appearance. He reports a case cured by iodide of potash, which had resisted all forms of local treatment.

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[1] Journal of Cutaneous and Venereal Disease. New York, June, 1883.

[2] American Journal of Otology, 1879, p. 76.

[3] Archiv f. Ohrenheilkunde, Bd. xx. S. 245, 1884.

Differential Diagnosis.—This disease of the auricle is to be diagnosticated by its history and by other manifestations of syphilis in the skin elsewhere, as alopecia, tubercles in the skin, scars, and a general syphilitic cachexia. It might be confused with epithelial cancer, from which, however, it may be known by its history, course, and objective symptoms. In the cancerous disease there is ulceration at the outset, whereas, in syphilis, there is first the well-marked deposit and subsequent ulceration. In cancer, there are well-marked everted edges to the ulcer; in syphilis, there are none. The secretion will offer another point of differential diagnosis, since in cancer it is thin, watery, bloody, and scanty, whereas, in syphilis, it is thick, yellowish, and copious. In cancer, furthermore, there is pain, while there is none in the syphilitic ulceration. The odor in syphilis is more offensive than in the cancerous disease. In the latter affection, the ulceration spreads peripherally from a single point; in syphilitic ulceration the breaking down is apt to occur at more than one point. It may always be known from eczema by the presence of deeper ulceration. Syphilitic ulceration might be confounded with lupus vulgaris, from which, however, it is to be distinguished by the history, lupus being more chronic, and the ulceration occurring at various points over the surface, but unattended by discharge. In lupus, a patch of varying size, from that of a pea to that of a small coin, first appears, being covered with small papules and tubercles from the size of a pin-head to that of a split-pea. These, in time, break down, and slowly ulcerate, are accompanied by a slight crusting and scaling of the epidermis, and characterized by marked cicatricial tissue.

The *treatment*, of course, is indicated by the syphilitic nature of the disease.

Idiopathic Herpes Zoster Auricularis.—In the course of inflammatory processes in the deeper structures of the ear, groups of herpetic vesicles and pustules appear upon the auricle, or very close to it. In the same way, herpetic patches appear on the auricle in cases of widely diffused facial herpes. But an altogether different state of things is found in cases of idiopathic aural herpes, which is developed only on the structures of the ear.[1] According to Gruber, this disease is one of the greatest rarities, for in 20,000 cases of diseases of the ear, he has observed only five instances of it. This disease attacks not only the parts of the organ of hearing supplied with true skin, but recently, Gruber has observed two cases in his clinic, in which, most probably, the herpetic disease extended to the drum-head and the cavity of the middle ear.

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[1] Die Bläschenflechte am Ohre., Monatsschr. f. O., Mai, 1875.

Herpes zoster auricularis, like herpes zoster in other parts of the body, manifests itself as an acute skin disease, accompanied by fever, and is characterized by the formation of vesicles and bullæ, which appear in groups and are attended with severe pain.

The *pain* in these cases of aural herpes exists usually many days, sometimes as long as two weeks, before the eruption occurs.

In a case which came under my observation recently, the patient stated that he was liable to severe earache and pains about the ear, which always terminated in a week or ten days by "an eruption of blisters," which I fully verified during one of his attacks. In this case, the eruption was confined to the meatus and tragus.

The pain is not always limited to the spot where at last the vesicles appear, but spreads out in different directions from the eruptive spot.

Nerves Implicated.—According to the investigations of Gruber, the nerves affected are the auricularis magnus, from the anterior branch of the third cervical; the auriculo-temporal, from the third branch of the trigeminus. He further states, that severe pain is usually complained of along the side of the neck and auricle, and the eruption appears much more frequently on the anterior surface of the auricle than on the posterior surface or in the auditory canal. Even in these favorite spots the vesicles and bullæ are more numerous in the tract supplied by filaments of the auricular branch of the pneumogastric nerve, and thus can be explained the fact that the eruption is more copious on the superior and anterior surface of the auricle than in any other part of it, and also why the posterior surface of the auricle remains almost entirely free. Perhaps the disease stands in close relation to fibres of the sympathetic connected with the nerves already mentioned as implicated in this affection.

The cause of this disease of the external ear is most probably the same as that which produces the disease in other parts of the body, viz., impoverished blood and consequent depraved innervation.

Symptoms.—Fever precedes the eruption, and in the graver cases may continue after the eruption has made its appearance, for the latter may come on in crops, with intervals between them. In one case given by Gruber, the fever continued thus twenty days in spite of all that was done. The crops of vesicles may succeed one another at the same points on the auricle, and the latter set will prove the most painful, since they produce deeper ulcers. The skin of the helix and of the fossa navicularis is most likely to be attacked with the severest eruption. While herpes of the auricle does not present any features of difference from that of the disease elsewhere on the surface of the body, it has decidedly peculiar features when found in the auditory canal.

When herpes appears in the *auditory canal*, the hearing is diminished and subjective noises are heard. The hearing returns slowly after all the herpetic symptoms have disappeared. The membrana tympani is affected in some cases, according to Gruber, and then the deafness is great, and there is great sense of constriction in the head. After the vesicles rupture, the disease amounts to superficial otitis externa diffusa. Gruber has scarcely a doubt that herpes occurs in the mucous membrane of the middle ear, basing his supposition upon the views of Bertholle[1] on herpes of the soft palate.

The *prognosis* of herpes zoster auricularis is favorable. While the ulcers left by it on the auricle may last for many weeks, the usual duration of the disease in its ordinary phases is from two to three weeks.

Previous to the publication of Prof. Gruber's paper on herpes auricularis, Dr. J. Orne Green, in a paper on "Neuralgia in and about the Ear,"[2] alludes to a case of herpes zoster of the small nerves supplying the helix, which he observed in a patient of Dr. A. F. Damon. "There was a well-defined herpetic eruption over the anterior surface of the helix, which had been preceded for some days by considerable remittent pain in that part, which disappeared on the appearance of the eruption; in a few days the vesicles dried up and the disease had subsided."

He also alludes to herpes zoster of the nerves supplying the tragus and meatus, and quotes from the case of zoster of these parts published by Dr. Anstie:[3] "The disease began with acute pain in front of the tragus, recurring regularly four times in the twenty-four hours, and darting up into the meatus, the maxillary articulations, and on the side of the head; there was no tenderness on pressure or abnormal appearance in the ear; a *point douleureux* existed just in front of the tragus. On the ninth day the pain began to diminish, and on the thirteenth herpetic vesicles appeared on the auricle, which from irritation became ulcerated and very susceptible to cold, which set up the old neuralgic pain; on the twentieth day all symptoms had disappeared."[4] Dr. J. O. Green[5] has subsequently reported a well-marked case of herpes zoster, preceded by pain, on the posterior surface of the auricle of a lying-in woman.

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[1] Herpes guttural en général, etc. L'Union Méd., 65, 68, 70, 1866.

[2] Transactions American Otological Society, 1874.

[3] Practitioner.

[4] J. O. Green, loc. cit., p. 569.

[5] American Journal of Otology, vol. iii., 1881, p. 185.

Herpes Zoster of the Tragus.—I recently saw in a young lady, 18 years old, under treatment for slight pruritus of the external auditory canals, a very well-marked instance of herpes zoster of the right tragus. Sharp pain for several days, quite intense at times, preceded an eruption of vesicles, which finally became pustular, and then desiccated, without forming ulcers. The patient was pallid, though apparently strong and active.

Treatment.—The treatment of this disease consists in the greatest attention to the general condition of the patient, and in local applications which will tend to prevent destruction of the deeper parts. Preservation of the vesicles is much more easily accomplished on the auricle than in the auditory canal.

In the latter region, the tendency appears to be not to form crusts, but the vesicle soon bursts and a purulent discharge is then set up with considerable pain. In such a case, Gruber uses a solution of sulphate of zinc.

In a second instance of this disease in the auditory canal, the same observer punctured the vesicle, leaving the epidermis as a protective covering; but even in this case the treatment had to be supplemented by the use of a solution of zinc.

Artificial opening of the bullæ on the auricle appeared to be followed by a much better result. The small, shallow ulcers which form in the latter case, are cured by the use of simple cerate. Where the pain is great, diachylon salve, to which tincture of opium is added, has been found of the greatest benefit; the salve being smeared on linen and applied to the inflamed spots.

The treatment recommended by Dr. Anstie in the case referred to above consisted in hypodermatic injections of one-sixth of a grain, twice daily, in the region of the auriculo-temporalis, protecting the painful external parts from the air by coating them with collodion, and the painful parts of the auditory canal by means of a warm simple ointment of tallow, keeping the meatus closed by cotton. He also thinks counter-irritation, by means of mustard or cantharides over the occipital triangle, might prove beneficial by reflex stimulation.

CHAPTER II.

MORBID GROWTHS AND INJURIES.

MORBID GROWTHS.

THE auricle may be the seat of various morbid growths, such as cysts, angioma, lipoma, myxosarcoma, vascular nævus, fibrous tumor, sarcoma, and epithelial cancer.

New formations of cartilage sometimes appear after frost-bite of the auricle, giving origin to numerous small, hard, and sensitive nodules, which may be both seen and felt throughout the cartilaginous structures of the pinna (p. 216).

Cysts.—The simplest growth on the ear is a cyst. That form of primary cyst known as *atheroma*, developed in the subcutaneous tissues, may attain a very large size, in some instances reaching a diameter of several inches. Its growth is slow; in the concha there may be found the variety known as *sebaceous* tumor. In both forms, inflammation may occur, and a natural cure ensue.

Treatment.—These growths should be extirpated by the knife, and their sacs cauterized.

Angioma.—Angioma or the formation of new vessels, especially the cavernous variety, may be found in the auricle. The origin of such a growth may be in the auricle, or may spread to it from neighboring tissues. These growths may present remarkable as well as threatening appearances in some instances, as has been shown in a case related by Dr. Chimani.[1] In this instance the tumor first showed itself, shortly after the birth of the patient, a strong, healthy boy. The new growth was at first 2 cm. in diameter, in front of the left ear, and of a soft consistence and bluish color. By the time the patient was five years old the tumor had become as large as a walnut, from which time until he was fourteen years old the growth increased rapidly in size, and one year later, when brought to Dr. Chimani, at the Military Medical School of Vienna, the Josephenum, the tumor included the greater portion of the left half of the scalp, was soft, elastic, slightly fluctuating, painless, pulsated distinctly, and could be diminished in size by pressure. The skin covering it was bright red, and of a higher temperature than the surrounding parts.

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[1] "Aneurisma cirsoideum." See Blake's Report: American Otological Society, 1874.

Angioma of the lobule only, has been observed and reported by Dr. Charles J. Kipp.[1] In this instance the growth occupied the left lobe of a man fifty years old, and seemed to have been caused by a frost-bite of the ear, twelve years previous, at which time he noticed a bluish spot on the outer side of the lobule of the left ear.

Vascular Nævus Maternus.—That form of vascular growth known as "mother's mark" may involve the auricle, together with parts of the adjacent cheek and neck. In a negress thus affected, the lobule and lower half of the helix were especially large and liable to engorgement, while the general appearance of the auricle was elephantine and grotesque. All such vascular growths are painless, but are liable to feel hot and heavy after exercise. The rest of the auricle may be somewhat hypertrophied, and if the growth invade the external auditory canal, the hearing will be impaired. Their vascular nature is very apparent by their color, their temperature, and compressibility, as well as by the pulsation which may be felt with more or less distinctness in all of them, and by the murmur which may be heard in some of the larger ones, as in the case reported by Chimani. In the latter instance the subjective symptoms were aggravated by the fact that the auditory canal was greatly implicated in the growth. There were headache, hardness of hearing, tinnitus aurium, and sensations of heat and beating on the affected side. When neglected, nævoid growths may become aneurismal and necessitate amputation of the pinna.[2]

Treatment.—The treatment of these vascular growths must always be modified by their position in or about the auricle, and by their size.

The treatment of angioma of the lobule of the auricle is comparatively simple, but treatment of larger growths involving the entire auricle and surrounding parts, and extending into the auditory canal, becomes of the greatest importance. It is even questionable whether heroic measures are ever justifiable in the latter instance.

In removing angioma of the lobule, the method followed by Dr. Kipp[3] is probably the best. I have used it with slight modifications, with entire satisfaction. It is to fasten the lobule in an ordinary entropion forceps, to control the hemorrhage, and then make an incision parallel and close to the lower border of the lobe. The skin should then be dissected off the tumor, and when the latter is fully exposed, the knife should be carried behind it, and its connection with the subcutaneous tissue severed. Healing by first intention usually ensues, and the lobule heals without any deformity.

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[1] Transactions American Otological Society, 1875.

[2] Mr. F. Eve, Med. Times and Gazette, London, May 8, 1880.

[3] Loc. cit.

For the cure of angioma, especially the larger forms, Gruber[1] has recommended various forms of cauterization, vaccination, the application of diachylon plaster and tartar emetic (ʒij–gr. xviij),[2] the subcutaneous injection of liquor ferri sesquichlorati, and acupuncture. He gives the preference, however, over all these, to rapid extirpation of the new growth, and in order to prevent the necessarily copious hemorrhage, recommends ligation of the large vessels supplying the parts, or the use of the galvano-cautery.

Subcutaneous injections of chloride of iron were used by Chimani, in the case referred to, with moderate success, but not enough to warrant the risks of inflammation and hemorrhage. The danger of the latter, as well as of sloughing, should deter the surgeon from adopting any form of treatment which would be likely to produce such results.

Fibrous or Fibro-sarcomatous Tumors of the Lobule.—Tumors of various sizes have been found on the lobule as the result of piercing this part of the ear for the purpose of wearing ear-rings. Deprès reports having observed mucous patches at the perforation of the lobule for ear-rings, in syphilitic patients.[3]

Gruber states that he has seen two cases in children, in whom small tumors, the size of a pea, appeared on both sides after the piercing of the ear several years before. In his opinion, these tumors had originated from granulations which, springing from the hole in the lobule, had developed skin on their free surface, and then become stationary. These tumors are composed, according to Billroth, of spindle-cells and connective tissue.

A similar variety of tumor has been observed among negroes by several writers,[4] and is attributed invariably to wounds inflicted by the piercing of the lobule, or the tearing consequent upon the enormous rings the lobule is obliged to support.

Some years ago, I observed two large tumors of this variety in a young and very fat negress (mulatto). There was no history of the lobules ever having been torn by the weight of her ear-rings, which were very large, nor of any wounding of the parts by the act of piercing. In this case it seemed that the growths had been brought about by the weight of the ornaments.[1]

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[1] Op. cit., pp. 409, 410.

[2] Zeissl, quoted by Gruber.

[3] American Journ. of Otology, vol. ii., 1880, p. 61.

[4] Langaard, Wiener Med. Wochenschrift, 1869. M. J. Bramley, Transactions of Medical Society of Calcutta, vol. vii., Saint-Vel, Gazette des Hôpitaux, 1864.

One tumor was as large as, and shaped like, an English walnut, with a large chestnut laid on it, and the other tumor was as large as the largest chestnut. I removed both tumors, and exhibited them at the Pathological Society of Philadelphia, where, in the remarks which followed from the members, it appeared that these tumors of the auricle, apparently produced by the improper wearing of ear-rings, had often been observed in this city, in negroes, and that they had usually grown again after removal; but the subsequent growths were just as benignant as the first. Their microscopic character was similar to that given by Billroth to the tumors described by Gruber. This peculiar tendency to benignant recidives has also been noted by Dr. R. F. Weir, of New York City; Dr. Bertolet, of Philadelphia, and many others.

Fibroma may be found in the concha in children, as reported by Bürkner.[2] Myxo-fibroma of the auricle has been observed by C. R. Agnew.[3]

Sarcoma of the Lobule.—M. Roudot[4] has described a case of sarcoma of the lobule, in a peasant woman, 42 years old. The tumor occupied the right lobule, was soft and ovoid, 5 mm. long, 3½ mm. broad, and 8 mm. thick. It grew very slowly for twenty years; during the patient's fifth pregnancy, it developed very rapidly, and included the entire lobule. The tumor appears to have been painless, for the most part, but sometimes during her menses the patient would complain of a burning pain in the auricle of the affected side.

In addition to the entire lobule, the tumor also included part of the tragus. The new growth was reddish and flat, with some eroded spots; on the hinder edge there was a pretty large ulcer; a second, smaller ulcer extended from the under part of the tragus out upon the skin of the cheek. The organ of hearing was otherwise normal, and there were no glandular enlargements. The lobule, together with a small part of the tragus, was amputated, and the wound did well for several weeks, when the patient voluntarily left the hospital.

Glandular Hypertrophy of the Lobule.—After inflammation of the skin of the lobule of the auricle, there may remain a chronic hypertrophy of the glandular structures, of a nature similar to those chronic enlargements met with in the cutaneous structures elsewhere in the body, after being invaded by inflammation. This is fully illustrated in the following case:

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[1] Similar cases recently reported by Buch, St. Petersburg Med. Weekly, 31, 1881; Habermann, Archiv f. Ohrenh., Bd. xvii. S. 29, 1881; E. E. Holt, Amer. Otol. Soc., 1883.

[2] Archiv f. Ohrenheilkunde, Bd. xvi. S. 58, 1880.

[3] Amer. Otol. Soc., 1878.

[4] Gazette Méd. de Paris, 1875, No. 26.

Bridget G., aged 22 years, a seamstress, states that at thirteen years of age she had an attack of erysipelas of the scalp, which involved the auricle to a marked extent. The auricle remained inflamed for six weeks, but then gradually lost all swelling, excepting at the lobule, which has remained about twice the natural size ever since. There has never been any return of the erysipelas of the scalp. At the time of first examination, the lobule, besides its enlargement, presented a livid, reddish hue, was shiny, scaly, and slightly erectile when manipulated, but not sensitive. Its surface usually presented a flaccid appearance, like a partially withered grape.

Treatment.—The under cutaneous edge of the lobule was dissected up for a quarter of an inch, and then a **V**-shaped incision was made, including the growth on the lobule. There was considerable bleeding from two or three spirting arterioles, which was finally controlled by ice. The edges of the cut were held together by a stitch; the wound healed by first intention, and without a trace of the incision.

The tumor thus excised, I submitted to Dr. Morris Longstreth, Pathologist to the Pennsylvania Hospital, in Philadelphia, who has kindly made most skilful sections, and written the following descriptions of the microscopic appearances of the tumor:

"The tumor shows varied histological and histioid elements; the preponderating constituent is an ill-developed epithelial cell, resembling the squamous variety and having a great diversity of outline.

"First of all can be shown the elements of normal skin, the papillæ with the covering corneous layers, and the hair-bulbs. There can be seen, in the deeper parts, the subcutaneous connective tissue, in which in places the vessels are large and numerous; around these vessels the fibrous tissues are denser and more abundant than usually seen in these parts; this fibrous tissue forms a sheath to, or a canal in which, the vessel is distributed. In and around the sheaths of the vessels are seen, in many places, deposits of adipose tissue, arranged in lines parallel to the main trunks and also following some of the smaller branches. So far, the appearances shown in the microscopic sections correspond to the normal histological elements of the skin, the papillary layer and the hair-bulbs seem normal, whilst the deeper layers are hypertrophied or hyperplastic; the connective-tissue parts appear overloaded or crowded with granular (or cellular) elements. No distinct cells can be isolated here, and the structure altogether presents a very confused picture.

"Between the dermic layers and parts further removed from the surface (viz., the parts which seem to constitute the tumor-mass proper) is a defining line; the line is not constituted of a bounding or limiting membrane, such as to be described as a capsule or basement-membrane; but there is to be seen a distinct differentiation of the one part from the other. This condition is well marked in some specimens.

"The inner area shows the same confusion or want of distinctness of arrangement. The cells approximate likewise to an epithelial type; some appearing like ill-formed or undeveloped squamous epithelial cells; others resembling young nuclear (embryonal formative) elements found in the lower strata of all membranous tissues; others again have the shape of columnar cells (perhaps this form may be due to close packing); still others appear of an elongated or fusiform character, or else as rounded cells of small size with bipolar filiform appendages of great tenuity. In all this inner area there is no trace of blood-vessel structure, nor of a stroma or intercellular network. There is no appearance of stroma of any kind, save that of the filiform cell-appendages.

"The nuclei of all these cells are of small size, and in a majority of instances so obscured by granular or fatty elements as to be scarcely visible. In some instances the cell-shapes, but not the cell-arrangement, approximate to that of the small spindle-celled sarcoma. This character cannot be maintained as the nature of the growth. There is no one type presented in such a degree as to lead to the classification under any histioid group.

"The only solution which presents itself, and that a problematic one, is that the new growth belongs in the main to the glandular structure, and with this has taken place a (sarcomatous?) growth in the surrounding connective tissue; that, under the erysipelatous irritation to which the lobe of the ear was subjected, in the first instance, some one or more of the glands became ectatic from the swelling and closure of the duct; and that, instead of its contents undergoing the accustomed degeneration, the consequence of the erysipelatoid hyperæmia, started by the erysipelas and maintained, in part, by the ectasy of the gland, there ensued a hypertrophy or hyperplasia especially of the underlying, more than of the superficial tissues. In other words, we have taking place an inflammatory new formation, in which especially participates the connective tissue, and this new-formed connective-tissue element has maintained, to a high degree, its hypervascular character (even to becoming somewhat erectile); and in this new growth, mixed elements share in the occupation of territory; on the one hand, cells which present a type tending to the epithelial character, on the other hand, coming out more conspicuously in the deeper parts, cells which in the fusiform character, verge toward the embryonal cells of a connective-tissue growth and give appearances calling to mind the sarcomatous new formation.

"There is, however, another element or character present which I cannot wholly pass over, viz., the glandular element. Not only is there to be seen the passing by insensible gradations from the papillary layer in what we may regard as a part purely, or nearly so, of subcutaneous connective tissue (however much this may be changed by overcrowding of cells), but this again passes over into an area of cells in which there can be seen no stroma-cells, some of which are columnar in character that may well be held to have to do with the recess of a gland in the condition of ectasy. The only supposition under which the glandular participation in the new growth, as a whole, is tenable, is that the gland elements, and especially their secretion, under the influence of the permanently increased hyperæmia, did not tend, as is their wont, to retrograde metamorphosis, in spite of the gland becoming ectatic and thereby retaining its secreting contents. Also, it must be evident that the inflammation-disturbances have something to do in producing a permanent alteration in the function of the affected glands—not a very difficult supposition, and quite within the range of experience."

Epithelial Cancer.—Epithelial cancer of the auricle has been described by Gruber,[1] Wilde,[2] Kramer,[3] Toynbee,[4] Demarquay,[5] J. Orne Green,[6] Gustav Brunner,[7] T. Bryant,[8] W. W. Seely,[9] and others.

It is said by Gruber to be the only malignant disease which occurs in the auricle primarily. It generally appears as a small nodule or wart in the skin of the auricle, which, being picked at in most cases, soon is found to be covered by yellowish scabs, the result of the hardening of a scanty discharge from the new growth. Beneath these crusts there is found an ulcer, with a not very rough base, somewhat disposed to bleed, and the edges of which are hard and uneven. After a rather slow destruction of the superficial tissues, the deeper structures of the ear may be invaded. The auricle may be destroyed in this way, and then the deeper parts of the ear become the seat of the cancerous disease. There is usually some pain, but it is not invariably severe; in some cases, however, it may be intense, as shown by Brunner.

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[1] Ohrenheilkunde, p. 416.

[2] Diseases of the Ear, p. 208.

[3] Op. cit., p. 204, quotes Fischer, 1804, "Krebs am Ohre," and Krügelstein, 1827, Allg. Med Annalen des 19 Jahrhunderts.

[4] Diseases of the Ear, p. 24.

[5] Gazette des Hôpitaux, Sept. 30, 1869.

[6] Transactions American Otological Society, 1870.

[7] Archiv f. Ohrenh., Bd. v. S. 28.

[8] Med. Times and Gazette, London, Jan. 6, 1872.

[9] American Otological Society, 1883.

Wilde alludes to *chimney-sweep's cancer* of the external ear, which is, however, in no way peculiar, excepting as possessing large amounts of pigment.

The *chronic inflammation of the cellular tissue* of the auricle, alluded to by Kramer, is in all probability a description of cancerous degeneration of the appendage.

Epithelioma of the auricle may interfere greatly with the hearing, the interference being proportionate to the advance of the disease into the auditory meatus. I have seen two cases of this disease in the auricle, the first of which occurred in a negress, fifty years old.

She stated, when I first saw her, that the growth on the ear was about six months old, and had been caused by a blow on the auricle with a loaded cane. I found the meatus almost entirely occluded by the growth, which appeared to have started from the region of the tragus, and had progressed rapidly inward, on the superior wall of the auditory canal, producing also some induration outwards toward the zygoma, its entire size being about that of a small English walnut.

The discharge was bloody and purulent, several drachms daily in amount, not very offensive, but of a peculiar odor. The ulcerated surface of the tumor pointed inwards, filling up the auditory canal. The hearing was reduced to almost nothing. There had been no disease of the ear previous to this, according to the woman's statement, which appeared to be reliable in all respects.

Excision of the growth was advised, as it had grown rapidly from a well-defined centre, but the patient refused, and soon after disappeared entirely from my notice.

I have seen recently another case of epithelial cancer, beginning at the tragus and upper front edge of the helix of the auricle, in a man aged 40. He had been under observation and treatment for the disease for more than a year when I first saw him. Gradually the cancerous degeneration advanced inward on the front wall of the auditory canal, hiding the anterior part of the membrana tympani from view. The cancerous growth was scraped away from the tragus, meatus, and anterior wall of the auditory canal, by means of a cutting spoon, January 30, 1884.

Dr. Gustav Brunner,[1] of Zurich, observed a case of primary epithelial cancer of the ear, in a female 56 years old, which proved fatal in the course of the year.

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[1] Archiv f. Ohrenh., Bd. v. S. 28.

The health of the woman had been good up to the time when a slight discharge came from the ear; previous to this there had been some itching in the ear, and she had scratched the organ with a hairpin, but there had been no deafness. For the slight discharge, she subjected herself to some kind of water-cure douche on the ear, and this was followed by intense earache and facial paralysis. Granulations in the meantime sprang up in the ear, which upon manipulation bled freely; pain in the ear became intense and constant, and, as it was concluded that the morbid growth had already reached the inner wall of the tympanum, no operation was advised. The ear was kept carefully cleansed, and the pain was eased by anodynes as far as it was possible. The auricle was at last dissected loose by the disease, and at several spots about the ear there was loss of substance. There was no post-mortem examination permitted.

In the early stage of this case, pain was the chief diagnostic difference between it and one of polypus or granulations in the ear. Microscopic examination of a piece of the granulating mass in the meatus revealed the true malignant nature of the growth.

Treatment.—The only beneficial treatment of epithelioma of the auricle is immediate excision of the growth, even if to do this it is necessary to amputate the entire pinna, as was done by Dr. Thaxter, in the case reported by Dr. J. Orne Green.[1] The hemorrhage which must naturally occur is to be controlled in the ordinary way by ligatures.

Healing may be slow, and in those cases in which the entire auricle has been cut off close to the skull, the granulations must be closely watched and prevented from closing up the external auditory meatus. This is best done by keeping some form of tent in the opening of the canal and by touching the granulations with caustics or by stimulating washes. The treatment will be eminently successful if the cancerous disease has not extended to the meatus and the drum; in the latter instance the disease may have advanced too far to be controlled by surgical interference.

Othæmatoma.—Othæmatoma, or blood-tumor of the ear, is characterized by congestion and heat in the auricle, and a rapid effusion of blood between the cartilage of the auricle and the perichondrium. The tumor, in the course of a few hours or a day, attains the size of a bean or an egg, the color of the auricle may remain natural or become purplish, and though the tumor is somewhat hot and dense, fluctuation can be detected in it.

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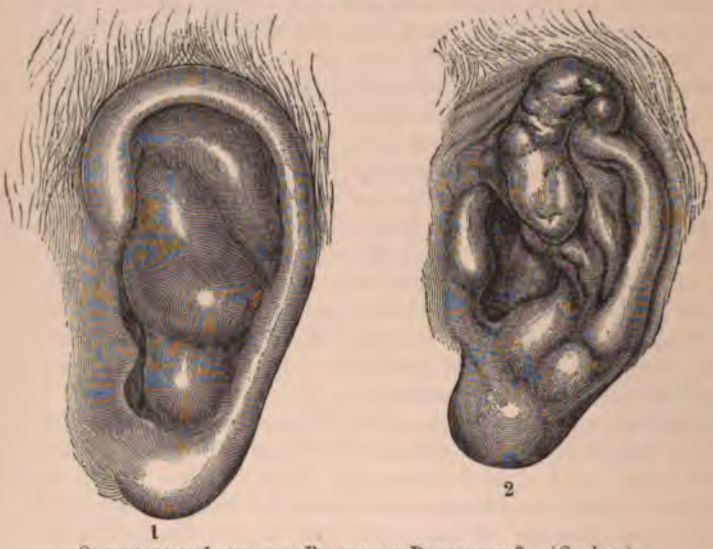
[1] Loc. cit.

There is some burning pain in the new growth, with a feeling of weight and distention. The earliest manifestations of the disease are rapid, but after the tumor is fully formed, it may remain apparently indolent for days or even weeks. At last it may rupture spontaneously, the most frequent mode of disappearance, or its contents may coagulate and absorption without rupture take place, causing considerable permanent deformity, but much less than when the tumor ruptures spontaneously or is punctured artificially.[1] Its occurrence is more frequently unilateral than ambilateral, but an attack on one side may be followed by an attack on the other;[2] the lobule is never attacked in this disease of the ear. I have recently seen a case of this disease occurring simultaneously in both auricles of a young lawyer, forty years old, affected with paresis of the insane, August, 1883. In an account of twenty-four cases of this disease, by E. R. Hun,[3] sixteen were unilateral, but in four cases the disease on one side was succeeded by the disease on the other, the first hæmatoma subsiding usually before the second ear was attacked.

Fig. 77.



OTHÆMATOMA 1, AND THE RESULTANT DEFORMITY 2. (Gruber.)

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[1] E. R. Hun, American Journal of Insanity, p. 23, 1870.

[2] Laycock, case of Othæmatoma under care of Mr. J. Hutchinson, Med. Times and Gazette, Dec. 1862, p. 603.

[3] Op. cit., p. 17.

The disease is more common in males than in females, only one of the above twenty-four cases being of the latter sex. The late Dr. I. Ray informed me that he had never seen this disease in females, whereas he had constantly met it in males. He furthermore stated to me, that, when in charge of insane asylums, he had constantly had cases of othæmatoma on hand, two or three at a time in old cases of chronic dementia, a noticeable feature of whose malady is their entire harmlessness and docility. So great is this latter characteristic, that they are made kind of under-nurses in the asylum, which fact would tend to prove that the disease in them is caused neither by blows nor falls, as they are not likely to be struck by others, and are perfectly able to take care of themselves.

Etiology.—This disease of the auricle has been the subject of much discussion, as to its cause, nature, and significance. Formerly it was considered entirely the result of violence, but later writers have denied its purely traumatic origin, and have given to it an important significance, inasmuch as they have described an idiopathic variety occurring most frequently or only in the insane,[1] asserting as its cause a disease of the brain, some authorities even localizing the exact seat of the cerebral disease in the restiform bodies.[2] Others, while admitting its most frequent occurrence in the insane, still cling to the idea of its purely traumatic origin, being of the opinion that the weakened and often helpless condition of the insane renders them most liable to violence to the auricles.[3]

In all probability there are two[4] distinct forms, the purely *traumatic* and the purely *idiopathic;* the first seen in well-known cases of violence to the auricle, as in boxers, and the insane who have been beaten by their keepers, themselves, or each other; and the second, so frequently seen in the paralysis of the insane, and in diseases of the restiform bodies as proven by experimental irritation of them in rabbits. Even in cases of insanity where the latter variety is found, the first variety has been observed too, but the difference of the two forms is very apparent. It is also asserted that the purely idiopathic variety has been observed in the perfectly sane.[5] Schwartze,[6] Wendt, and Blau[7] have observed such cases. But even granting that at the time of the occurrence of the othæmatoma in these cases the subjects were sane, they certainly presented grave symptoms, for their malady could but be regarded as indicative of disease of the brain, which had not yet, it is true, culminated in insanity,[1] but which would render their future sanity very problematical. "When we consider the intimate connection between the circulation in the ears and that of the rest of the head, we cannot but acknowledge that any disturbance in the circulation in the brain is prone to produce a corresponding alteration in the circulation of the ears. Now, in all chronic cases of insanity, and especially in general paresis, we find a tendency to repeated congestions of the head, and under such circumstances it is natural to suppose that the bloodvessels of the ears become gradually dilated, so as to favor the occurrence of an effusion of blood. It is idiopathic, depending upon a pathological condition of the brain, and is incapable of being produced by violence alone."[2]

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[1] E. R. Hun, American Jonrnal of Insanity, vol. xxvii., 1870.

[2] Brown-Séquard, Lecture in Univ. of Penna., Oct. 10, 1872.

[3] Thurnam and Toynbee; Toynbee on the Ear, London, 1868, p. 21. Von Troeltsch, English Transl., 1869, p. 50

[4] Gruber, Lehrbuch der Ohrenheilkunde, Wien, 1870, p. 281.

[5] Roosa, Treatise on Diseases of the Ear, two cases by Roosa, and one case by Loring; also a case by Gruber. Lehrbuch d. Ohrenheilk., p. 283.

[6] Archiv für Ohrenheilkunde, vol. ii. p. 213, and vol. iii. p. 29.

[7] Ibid., vol. xix. p. 203. The patient was fifteen years old.

Some of the earliest writers on this disease called it erysipelas of the auricle; but, of course, that view was erroneous. This disease may make its appearance on the posterior surface of the auricle, though rarely,[3] and is called by Kramer[4] a perichondritis of the auricle. This author also asserted its frequent occurrence in the insane, but very rarely in others. He states, however, that Langenbeck had seen two cases in the sane, and Heyfelder one case in a healthy miller, in whom the tumor occurred with pain after epistaxis for several days.[5]

Dr. Kirkbride, of the Pennsylvania Hospital for the Insane, and Dr. Curwen, of the Pennsylvania State Lunatic Asylum at Harrisburg, are inclined to the opinion that othæmatoma is usually the result of violence, and almost invariably confined to males.[6] Dr. J. H. Worthington,[7] chief physician to the Friends' Asylum for the Insane, at Frankford, Philadelphia, who has observed and treated a large number of cases of this disease of the auricle, has never seen a case of this affection in a *sane* person, nor in a case of curable insanity. He always considers this affection of the ear as an evidence of the incurable form of insanity, such as he has described as "congestive mania." From the observations of Dr. Worthington, it appears that othæmatoma is always associated with a tendency to congestion of the membranes of the brain or the cerebral substance itself, in which opinion he is nearly in accord with Dr. Laycock,[8] who thinks "that the states of the circulation, nutrition, and development of the tissues which make up the ear, lobule, and cover the helix, very commonly coincide with similar conditions of the encephalic tissues."

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[1] Brown-Séquard; Roosa, Treatise on Diseases of the Ear, p. 112, 1873.

[2] Hun, American Journal of Insanity, 1870, vol. xxvii. p. 24.

[3] Allgemeine Zeitschrift für Psychiatrie von Damerow, 1848, vol. i; Rau, Ohrenheilkunde, p. 167.

[4] Die Erkenntniss und Heilung d. Ohrenkrankheiten, Berlin, 1849, p. 212.

[5] Rust's Magazin, 66 Bd. 2 Heft, S. 297.

[6] L. Turnbull, Clinical Manual of Diseases of the Ear, 1872, pp. 138, 139.

[7] Ibid.

[8] Med. Times and Gazette, March, 1862, p. 289.

That the origin of othæmatoma may be purely nervous, is proven by experimental irritation of the restiform bodies. Brown-Séquard[1] states that this variety of tumor is the result of disease at the base of the brain, and is usually found in the paralysis of the insane. It may be produced artificially in animals, and this he has done in less than one night, between the hours of ten in the evening and six o'clock in the morning. He has performed such experiments, and kept the animal *under his own eye*, until the artificially produced tumor made its appearance. This he accomplished by an irritation applied to the restiform body, on the side corresponding to that of the tumor. The lecturer also drew attention to the fact that these tumors usually occur, in the insane, on that side corresponding to the affected side of the brain, which proves that they cannot be, at least not always, the result of violence on the part of the patient or his attendants; since violence of any kind would not be applied invariably to the side of the head nor to the ear corresponding to the affected side of the brain.

Dr. Yeats,[2] of the Coton Hill Institution for the Insane, England, believes that the cartilage is the seat of this affection, and that hence the lobule of the ear always remains intact. He has not found othæmatoma prejudicial to hearing; on the contrary he has observed that the hearing became sharper in some instances during the disease. He has further observed that this affection of the ear is not confined to any particular form of insanity, although it is frequently found in dementia; that it never occurs in the sane, and that the prognosis of mental recovery in those affected with idiopathic othæmatoma is extremely unfavorable. In all his experience he knows of but one case of insanity in which recovery ensued after the appearance of this unfavorable symptom. The patient, a married female, thirty-three years old, was admitted to the aforesaid institution; thirteen months afterwards, in the midst of every variety of bad symptoms, othæmatoma appeared, and, after running its course, disappeared. Finally, the patient began to show signs of mental recovery, and was discharged from the asylum perfectly restored to reason, after three years of insanity.

With the evidence thus gained it would seem that the inevitable conclusion must be, that the occurrence of idiopathic othæmatoma is found either in the hopelessly insane, or in those about to become so from cerebral disease which has induced the pertaining to this subject up to the time of the publication of his book, is decidedly in favor of using, at the commencement of the disease, cold lead-water dressings, which he advises to be used until the tumor begins to soften a little, then they are to be removed and warm fomentations of arnica used in order to favor resolution and absorption. He is of the opinion that incisions into the tumor are *almost always* injurious, yet they are preferable to the method of acupuncture as suggested by Speyer, for the former operation removes more thoroughly the coagula. Saxe, according to Rau, recommended, after the incision and the removal of the coagula, the application of dressings of alum and water (2 drachms to f℥iv), and to cover the entire ear with cotton-wadding. As we have already seen, Hun[1] disapproves of incisions in any case of othæmatoma, and Kramer[2] approves of general roborants and cool dressings at first, until the tumor begins to soften, then absorption may be promoted by the use of dressings of tincture of arnica. But he is opposed to all incisions and surgical operations in these cases.

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[1] Lecture in the University of Pennsylvania, Oct. 10, 1872.

[2] British Med. Journal, June 21, 1873.

Dr. Kirkbride[3] has found the application of ice and tincture of iodine most useful; the latter may be applied twice daily. He has not found the ear disposed in any case to resume its original shape. Dr. Worthington[4] disapproves of incisions as useless.

Kneading, or massage, has been recommended as aiding in absorption of the effusion. Massage and the pressure-bandage may be continued for some weeks, and in one case reported by Meyer,[5] the auricle, under this treatment, became absolutely perfect, excepting a slight thickening.

Othæmatoma in the Sane.—Some writers have recorded instances of what they have termed spontaneous othæmatoma in the sane; but in most instances, the cause of this disease in the sane can be traced to various traumatic influences, as boxing, and blows[6] on the auricle from many other causes,[7] burns, scalds,[8] and exposure to intense cold.[9] The more clearly traumatic cases have also been termed spurious othæmatoma, to distinguish them from the truly symptomatic variety occurring in the sane. It is most frequently observed among males, though the case reported by Dr. Blake was that of a woman thirty years old, who had been struck on the ear in falling. In this instance, an abscess ensued in the injured auricle, and after painful suppuration, discharged an ounce of pus.

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[1] Loc. cit., p. 23.

[2] Die Erkenntniss und Heilung d. Ohrenkrankheiten, Berlin, 1849, p. 214.

[3] See Turnbull, op. cit., pp. 138, 139.

[4] See Turnbull, op. cit., pp. 132–140.

[5] Wm. Meyer, Archiv f. Ohrenheilkunde, Bd. xvii. S. 2. C. J. Blake, American Journal of Otology, vol. iii., 1881, p. 193.

[6] C. J. Blake, Statistical Report of 1652 Cases of Ear Disease, 1872.

[7] Trautmann, Cases of Ear Disease in Garrison, at Breslau, Prussia; Archiv f. Ohrenh., Bd. ix. S. 183.

[8] C. J. Kipp, Transactions American Otol. Soc., 1873.

[9] Gustav Brunner, Archiv f. Ohrenh., Bd. v. S. 26–28, 1870.

As this disease has been noted among soldiers in a garrison, it is fair to presume that it is the result of rough sport in which they receive severe blows on the ear. Not uncommonly the traumatic variety of othæmatoma occurs among boys, receiving hard hits on the ear in playing foot-ball, as stated by the late Mr. Hinton, of London.

One of the most remarkable accounts of the traumatic origin of this disease is that given by Dr. Brunner, of a man forty years old, who, in riding all night in a very cold railway car, fell asleep with the auricle against the window-pane, to which the auricle was frozen fast. The rarest instances of traumatic othæmatoma are those resulting from burns or scalds, as in the case related by Dr. Kipp. The prevalence of this form of injury among boxers is so common, that it is shown in ancient statues of noted athletes, as pointed out by Virchow.

Diagnosis.—The diagnosis will not be difficult, as the history and general condition of the patient will usually plainly indicate the traumatic origin of this variety of blood-tumor of the ear. Most of the symptoms are sthenic, whereas the asthenic and indolent character of the tumor in the insane is very marked, and hence distinctive.

Treatment.—The treatment of traumatic othæmatoma should consist in opening the sac if suppuration has ensued. But if the latter process shall not have taken place, the symptoms of heat, congestion, swelling, and pain must be combated as in the idiopathic variety, viz., by application of ice and iodine.

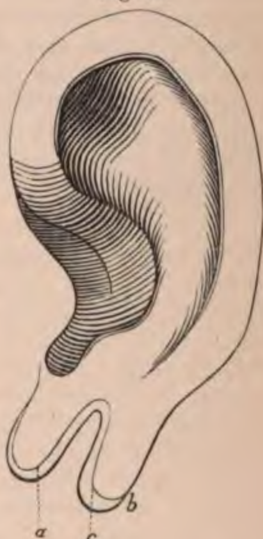
If it be necessary to open the sac to evacuate the pus which may have formed, the cavity should be gently stimulated by injections of weak solutions of carbolic or salicylic acid, and the walls kept in contact by gentle compresses. It will be found that with proper management the auricle can thus be kept from much deformity.

INJURIES OF THE AURICLE.

The general surgeon is often called upon to treat a variety of wounds of the auricle, but it is hardly in place to treat of them here. Most of these are caused by quarrels, and are inflicted by weapons, blows, and bites. Those caused by weapons appear to be somewhat peculiar to the countries where they occur, as in the French soldiers, whose auricles were so frequently injured by the yataghan in the battle of Constantina;[1] in Ireland, auricles have been split and bruised by the blackthorn stick;[2] and in Germany, the student's "schmiss" is often obtained by a sword-thrust or slash at the auricle. The treatment will consist in adjusting the wounded and displaced parts, keeping them in position by a stiff dressing, or by pins and ligatures coiled about them in shape of a figure 8,[3] and attention to the general principles of surgery.

Traumatic Cleft of the Lobule.—A not uncommon injury of the auricle is one caused by tearing out the ear-ring, and thus leaving a cleft of the lobule. This is produced most frequently by children in play with their mothers, but it is also done in fights between women. I have seen lately two sisters, both quarrelsome, in whom the lobules were cleft, one in three places, making four teat-like appendages, or fringe, said to have been caused by her babes, but the other woman acknowledged that in a quarrel with a female acquaintance, the ear-ring had been intentionally torn from her ear by her adversary. In both of these women the deformity had existed for several years.

Fig. 78.



Treatment.—If such cases are treated as soon as they occur, union by first intention can usually be effected; I have never seen any but chronic cases. Dr. Knapp, of New York, has lately suggested[4] a very neat and practicable operation for removing the deformity in such cases, without leaving the notch on the edge of the lobule, so common after operations on this part.

This operation is a modification of the Mirault-Langenbeck operation for harelip, applied to the auricle, and consists in the following method: Thrust a narrow-bladed scalpel through the anterior part of the lobule near the lower end of the slit (at *a*, Fig. 78), sever a thin slice of skin along its edge, and when the other end of the slit is nearly reached (at *c*), make the slice a little broader, leave its end (at *b*) in connection with the auricle, then go backward about two lines, and cut across the detached slice (at *c*), thus forming a small flap (*c b*). Now seize the long portion of the slice with a pair of forceps, and divide with the knife its other end (at *a*) by a slightly curved section. Without waiting long for the cessation of the bleeding, the edges of the wound may be gently but securely united by three interrupted sutures. The first is applied to the middle of the edges on the anterior surface; the second, about opposite the first, to the posterior edges. The curved needles need not penetrate more deeply into the substance of the lobule than about one-third of its thickness. By the third suture, the small flap (*c b*) left at the posterior part of the lobule, is made to bridge over the lower extremity of the gap. The needle, therefore, is first thrust through the free end (*c*) of the little flap, and then through the lower edge of the wound in the anterior portion of the lobule, the suture tied, and the operation is finished. No dressing is required. In three days the sutures are removed. Immediate union is usually obtained.

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[1] Wilde, op. cit., p. 164.

[2] Ibid.

[3] Dartigolles, Journal de Médicine de Bordeaux, 28th Dec. 1878. See Amer. Jour. of Otol., vol. i., 1879, p. 155.

[4] Archives of Ophth. and Otol., vol. iii. No. 1.

I have frequently tried this method, and found it the only means of preventing the notch so often seen in the lobule after it has healed.

SECTION III.

EXTERNAL AUDITORY CANAL.

CHAPTER I.

CIRCUMSCRIBED AND DIFFUSE INFLAMMATION.

OTITIS EXTERNA CIRCUMSCRIPTA consists in a circumscribed inflammation of the skin or subcutaneous cellular and fibrous tissues of the auditory canal, terminating in a small abscess or boil, which, in discharging its contents, produces considerable destruction of the skin covering it. Its seat is not confined to any particular portion of the auditory canal, but as it is most likely to occur in a region rich in glands, it is apt to be found in the outer part of the meatus. It may, however, arise in the deeper cellular tissues and in the periosteum of the bony portion of the auditory canal. Circumscribed inflammation of the external auditory canal may arise sporadically or epidemically, and, in the latter instance, it is a striking fact that the abscesses are confined to a particular part of the auditory canal.[1] Bonnafont[2] has recorded such an epidemic, occurring in Paris, in May and June, 1863, and Gruber[3] reports the occurrence of a similar endemic attack of this disease in the summer of the same year in Vienna, at which time, the majority of the abscesses were found in the outer third of the auditory canal, near the tragus.[4] Löwenberg has suggested that furunculosis of the external ear may be caused by the presence in the blood of a peculiar microbe. He claims to have found it in the pus of a freshly lanced boil in the meatus.

Symptoms.—This disease is usually extremely painful, and is attended with fever and even considerable cerebral symptoms in some cases. The boils usually occur one at a time, but the series may amount to a dozen. Sometimes they appear to merge so fast into one another, that the ease gained by the discharge of one is hardly enjoyed by the victim until the throbbing and burning pain of a new one warns him that he must endure the torment of another. The auricle may become sensitive to the least touch and traction, especially if the abscesses are in the cartilaginous part of the canal, and the patient then cannot endure the ordinary pressure of the affected side of the head on the pillow. But such sensitiveness of the ear is not so likely to occur in this form of otitis externa as in the diffuse form. The severest pain and most distressing symptoms are found when the boil is seated in the unpliable parts of the bony portion of the canal; intense distress, however, may be caused by a boil seated just within the opening of the auditory canal. Usually, the gravity of the pain and febrile symptoms will depend upon the depth of the abscess in the tissues of the auditory canal, as well as upon its proximity to the drum-head. Small superficial abscesses do occur in the meatus without any pain, a sense of discomfort and dulness of hearing having been the only cause of the patient's seeking surgical relief. More than one such case has been seen where the abscess had run its full course and was on the point of discharging without having caused the patient any pain. But, of course, such cases are great exceptions, and are explained by the superficial seat of the inflammation. Hardness of hearing and deafness are prominent symptoms of furuncles in the auditory canal. In some cases the deafness is almost absolute, and the congestion being so great, and extending consecutively even into the cavity of the tympanum, the deafness is the last symptom to disappear. But the patient can be assured of the ultimate return of the hearing in such cases if there has been no organic lesion of the drum-cavity. As such a lesion is a very unlikely occurrence in this disease, there is every hope of the return of the hearing.

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[1] Gruber, Lehrbuch d. Ohrenh., p. 297.

[2] L'Union Médicale, 1863.

[3] Bericht Allg. Krankenhaus, Vienna, 1863.

[4] See American Journal of Otology, vol. iv., 1882, pp. 139–144. A review by J. J. B. Vermyne.

Inspection of the auditory canal and membrana tympani is usually very difficult if the disease is advanced and the swelling of the meatus considerable. This difficulty is less likely to occur when the disease is in the cartilaginous part of the ear, for with care it may be gradually stretched by the speculum. When the disease is in the bony portion of the canal, one can usually obtain a view of the drum-head only in the earlier stages of the disease. In such cases, if the abscess is seated near the drum-head, it will be seen that the latter is more or less congested at that point nearest the abscess, and in many cases where the boil is near the periphery of the membrana tympani in its upper half, considerable swelling will be found in the region of the membrana flaccida and the folds of the drum-head. In such cases, at first sight, one may be inclined to diagnosticate the disease as myringitis, but the history of the case, and the comparatively normal condition of the drum-head, excepting at the points of secondary congestion produced by the circumscribed inflammation of the canal, and the greater pain in the latter disease, will make the true diagnosis easy. When the abscess in the bony portion of the canal becomes fully developed, the view of the drum-head will be entirely cut off, and the deafness and tinnitus become great. After the discharge has occurred, the drum-head may be seen as a red, and somewhat sodden membrane, which, however, in a few days, gradually assumes its normal color and outline, and the hearing will be found to be returning.

Inspection of the auditory canal and drum-head by means of the ear-funnel, unless carefully done, becomes very painful to the patient with this disease of the ear; but it is very important to examine the canal well, in order to determine the seat, the quantity, and the stage of the disease, as well as to be assured of the absence or the presence of exostoses, cerumen, or other foreign bodies in the canal, which might interfere with the escape of the products of inflammation and greatly complicate the disease. Having established the presence of either or all of these complications, the surgeon must mitigate the effects of the exostoses, and remove, if possible, any other obstructions, such as cerumen, foreign bodies, etc., by the most gentle and thorough syringing, or by the most careful manipulation.

If exostoses are in the auditory canal, care must be taken not to mistake such rounded prominences for the furuncles. This, in some cases, may prove to be no easy task, and, therefore, as these growths, if congenital, are usually in both canals, if there be any suspicion that the affected ear contains such bony growths, the well ear should be examined, and if it contains them, caution should be observed in ascribing all the swelling in the diseased ear to the furuncles. However, as these prominent growths of bone are not very frequently seen in the ear, they will not often be found as complications in circumscribed external otitis, but it is well to bear in mind the possibility of their presence in the affected ear.

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Fatigue and consequent debility from any cause may produce them; and it is not uncommon to find furuncles in the auditory canal of young devotees to fashion, after a long and gay winter season with its round of parties and fatiguing attendants of late hours, bad air, indigestible food, and loss of sleep. I have never seen this disease in children.

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With the meatus lighted as well as possible by the aid of the forehead-mirror, though in some cases direct light will be sufficient if the furuncle is not too far down the auditory canal, and while the head of the patient is allowed to be entirely free, the surgeon may make a thorough and deep cut into the small abscess, taking care that the patient is allowed to jump away from the operator rather than towards him, an end best gained by allowing the patient's head to be entirely unsupported, on the unaffected side, *i. e.*, the side opposite to the operator.

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In the interval between the syringings, or just before them, a solution of bicarbonate of soda, gr. x–xx to f℥j, or of biborate of soda, gr. x to f℥j, may be instilled into the meatus in quantities of from ten to fifteen drops warmed. These, by remaining in contact with the affected spot, will soften any hardened crusts of the discharged matters from the abscess and facilitate their removal by the syringe.

As has already been said, the occurrence of a small abscess or boil in the auditory canal, denotes that there is a tendency towards the occurrence of another or several in the same spot. Hence, the constitutional, as well as the local, treatment becomes of the greatest importance. Some observers have asserted that chronic furunculosis of the ear is a symptom of diabetes mellitus. I have observed one case of chronic furunculosis in the meatus, the middle ear being unaffected, in a diabetic woman.

Whatever is employed for the cure of boils, when occurring elsewhere in the body, should most surely be employed when they make their appearance in the auditory canal, for they are not only an evidence of the need of an alterative treatment, but they are intensely painful and interfere with hearing.

At the head of the list of remedies stand iron and quinine, while in some cases iodide of potassium has been found most efficacious in breaking up a tendency to the formation of boils. But there is no specific in this malady, and if one form of treatment does not bring about the desired result, another must be tried, until the disease disappears. Most frequently the best results will be gained from those remedies which improve the general condition of the patient. Von Troeltsch strongly recommends the internal use of Fowler's solution in this disease.[1]

Dr. Samuel Sexton recommends the administration of the sulphide of calcium, as do others, in this disease of the ear. I have tried it in doses of one-tenth of a grain three or four times daily with undoubted success. This drug seems to induce resolution of the inflammation, and hence, in such cases, the necessity of an early incision into the swelling in the canal is done away with.

Local Treatment.—Although local causes have very little to do with this disease of the auditory canal, it will be found advantageous to combine a local treatment with the giving of medicine internally. The use of some soothing or mildly stimulating salve, as the case seems to demand, has been found apparently to diminish the tendency to recurrence of the abscesses and to favor an early return to healthy action on the part of the various cutaneous structures. As a soothing application, nothing is better than a little cold cream smeared on a camel's-hair pencil and then painted round the walls of the meatus. In the early stages I have found the application of black wash soothing to the pain and smarting. The ice-bag carefully applied will ease the pain of a boil in the meatus.

If a more stimulating ointment is needed, the following will be found to answer very well:

℞—Hydrargyri ammoniati, gr. i–ij.
Ung. aq. rosæ, ℥j.—M.
Ft. ung. S. Apply to the ear with a camel's-hair pencil.

A small portion of this ointment may be smeared on and around the affected spot, twice or thrice daily, by means of the hair-pencil, for several days, until the skin of the auditory canal appears to be free from the tendency to the formation of these small and painful abscesses. Painting with iodine around the auricle is claimed by Blau to prevent recurrence. If there is no return of the abscesses, the congestion soon goes from the drum-head, and the hearing will be restored.

The granulations sometimes left by a furuncle in the ear are best treated by cauterization with a saturated solution of nitrate of silver, applied by means of a little cotton on the holder. As the granulations are distinctly marked centres of disease, touching them is much safer than instillations applied to them. Insufflations of boric acid are often sufficient to cause the granulations to disappear.

A fuller consideration of the best treatment for polypoid granulations following external otitis will be found further on, where polypoid diseases are specially alluded to.

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[1] Diseases of the Ear, 2d American edition, p. 102.

Diffuse Inflammation of the External Auditory Canal.—This disease affects the osseous part of the auditory canal usually, but it may at the same time invade the cartilaginous portion and even spread to parts of the auricle in some cases. The only essential difference between it and the disease treated of in the preceding pages, otitis externa circumscripta, consists in its tendency to diffuse distribution to the entire external ear. It does not always originate in the same layer of the lining of the auditory canal. "A simple erythema of the cutis in the auditory canal may be considered the lightest form of the disease, and a periostitis of the canal may be called the severest form."[1]

Just as the circumscribed inflammation in the auditory canal shows the peculiar tendency to narrow itself down to a very minute and true abscess, the diffuse form of otitis externa shows the peculiarity to spread rapidly to all parts of the external auditory canal.

A pure form of periostitis of the external auditory canal never occurs, for the disease is never confined to the periosteum, but from the outset, all the neighboring layers of the wall of the canal are attacked. This is due to the fact that the skin of the canal is more firmly united to the periosteum than the periosteum is to the bone. Hence, an inflammation of the cutis readily extends to the periosteum and the bone, this being most probably the usual course of the disease. There is also a consecutive form of external otitis found in cases of acute otitis media. This always begins at the fundus of the canal.

Symptoms.—The subjective symptoms of diffuse external otitis are more severe in the primary than in the consecutive form.

In the former instance, pain, tinnitus, and deafness are the prominent and very distressing symptoms. Itching in the meatus is a constant, but frequently disregarded, symptom of the approach of this disease.

In general the subjective symptoms do not differ greatly from those of the circumscribed external otitis. In the so-called diphtheritic form the pain is said to be intense, continuing without any interruption day and night until the inflammatory product has assumed another character. The deafness and tinnitus in diffuse external otitis are more marked and more obstinate than in the circumscribed otitis.

The consecutive variety of diffuse inflammation of the external ear is, as a rule, less painful than the primary variety. This feature is most marked when the inflammation of the external ear is consecutive to purulent inflammation of the middle ear.

The *objective* symptoms of diffuse external otitis vary with the position, cause, and grade of the inflammation, being more severe in the primary than in the consecutive form. When the inflammation is situated in the bony portion of the canal, the disease assumes the nature of a periostitis with intense and continued pain, whereas the symptoms are not so severe when the disease seems to be limited to the outer part of the auditory canal. At the beginning of the disease the skin of the auditory canal is more or less swollen and red, and, in some cases, portions of the cutaneous lining of the auditory canal may be excoriated or even exfoliated at certain points.

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[1] Gruber, op. cit., p. 334.

Usually the redness and swelling are most marked in the bony portion of the canal, with, of course, great narrowing of the calibre of the canal, so that the latter appears to run to a point, thus assuming a conical shape. The skin of the fundus of the canal becomes puckered by the swelling, and one, perhaps more, of the ridges thus formed will shut off the drum-head from view.

The congestion and swelling, when the disease is at the fundus, are greatest in the region of the posterior periphery of the drum-membrane, and the vessels supplying the hammer and the membrana flaccida. The entire drum-head soon loses its gray color and its contour, so that the wall of the canal and the membrana tympani cannot be distinguished from each other by their appearances, and appear fused into each other, especially at the posterior border of the membrane.

All traces of the normal pyramid of light are lost, and the infiltration in many cases is so great that the consequent puckering of the drum-head will cause several shining spots to appear on the prominent points thus produced by the swelling of its layers, when light is thrown into the canal from the mirror. The appearance of the inflamed parts is somewhat changed when the layers deeper than the skin of the canal are more diseased than the cutis itself.

In such cases the swelling of the structure beneath the cutis will push it so much out of place that the two sides of the canal will be made to touch each other, and not even the narrowest speculum can then be pushed between them so as to gain a view of the deeper part of the auditory canal and the drum-head. Very often in such cases, since the superficial layer of the skin of the passage is very little diseased and remains quite dry, it may be somewhat difficult to say whether the disease is diffuse or circumscribed inflammation of the canal. However, in the former case we shall usually find more or less glandular swelling and tenderness about the ear, with pain on moving the jaw. Most important symptoms in some cases are the redness and swelling, with some œdema, of the mastoid process, because the surgeon may be misled into diagnosticating mastoid disease.

The glandular tenderness under and in front of the auricle is, however, a much more frequent attendant of this disease of the auditory canal, than the mastoid redness and tenderness.

The discharge of the products of inflammation in this disease may occur from several points, but usually it comes from one only. In the former instance the disease manifests symptoms similar to those of circumscribed external otitis, whereas, in the latter instance, the symptoms are peculiar to a true diffuse external otitis. In such a case, the discharge is remarkably copious, beginning as a discharge of colorless or bloody serum, and terminating in the course of a few days in a less copious purulent discharge. The amount of odorless bloody serum at the beginning of the discharge is so abundant in some cases, as to require the constant holding of a handkerchief to the ear, in order to protect the bedding or the clothing of the sufferer, and thus several handkerchiefs, in the course of the day, may be soaked with the discharge. The most marked instance of a flow of this kind the author has ever seen, was from the ear of a Japanese naval officer, from whom the discharge was very red as well as very copious, so red, indeed, that the patient considered it blood. It continued three days, and was succeeded by a light-yellowish discharge of purulent matter, exfoliation of epidermis from the fundus of the auditory canal and drum-head, with perforation of the latter by external erosion in the postero-inferior quadrant on the eleventh day. The brief mention of this case leads naturally to the statement that many cases of this disease, when situate in the bony portion of the canal, are attended with exfoliation of large pieces of epidermis and perforation of the drum-head from *without* inward. Perforation of the drum-head does not occur frequently as a result of the ordinary course of the disease, but great caution in the use of the syringe should be observed at the stage of exfoliation, for fear of penetrating the drum-head by the force of the stream of water. The swelling and exfoliation of the soft parts of the canal may be so great as to increase the pain and distress of the patient by a further distention of the canal, and the renewed irritation of the diseased part may reproduce considerable fever, which, however, subsides as soon as the exfoliated matter and discharge are removed.

Where it is impossible to gain a view of the drum-head on account of the narrowing of the auditory canal, resort may be had to the catheter, the use of Politzer's bag, or Valsalva's method of inflation, in order to ascertain the condition of the Eustachian tube and middle ear. This is often of the greatest moment, not only in children in whom it is often difficult to make a perfect diagnosis in this disease, but also in adults, in order to determine whether or not the external otitis exists alone or is accompanied by deeper and more serious disease in the drum-cavity. All the objective symptoms in diffuse inflammation of the external ear are modified by their causes and the diathesis of the patient. Hence, peculiar symptoms may be expected in that form of the disease produced by the presence of vegetable or animal parasites in the ear, in the diphtheritic form of the disease, and in any form in syphilitic or scrofulous individuals as well as in any traumatic case occurring in the more healthy, for in the latter instance the means by which the disease has been produced must be taken into account, since almost invariably it will complicate and alter the symptoms.

The *diphtheritic* form of diffuse external otitis is very rare, being unmentioned by many authorities. According to the best observers, it is never a primary affection, but rather an occurrence in the later stages of an inflammatory process. This form of the disease is usually found in scrofulous subjects in whom the original inflammation has been either neglected or improperly treated. In all such cases, after the usual purulent discharge has lasted a longer or shorter time, there is a sudden increase of pain and fever, with the simultaneous appearance of a white diphtheritic membrane, which adheres most closely to the inflamed structure, and when even lightly touched causes intense pain and some bleeding of the parts beneath, as shown by Gruber. Moos,[1] and G. A. Callan,[2] have each reported a case of idiopathic diphtheria of the external auditory canal. Jacobson[3] reports three cases of diphtheritic inflammation of the canal, observed in Lucæ's clinic. Bezold,[4] of Munich, reports three cases of fibrinous exudation from the walls of the canal and the membrana tympani.

In children there is often found, at the termination of an attack of diphtheria, inflammation in the external ear. This rapidly extends, in some cases, directly to the bone of the canal, and backwards to the mastoid process. Pain is not a prominent symptom in these inflammations following diphtheria, and this fact will readily distinguish them from the truly diphtheritic form of external otitis in which the peculiar false membrane is found in the auditory canal. The form of the disease now referred to is one arising from the broken-down condition of the little patient, rather than a form of disease already described as the diphtheritic. In the former case the pain is not great, the swelling is considerable, and the tendency to attack the bone is marked. Fluctuation is soon felt over the mastoid region, and, after the evacuation of the pus, the bone beneath is found denuded, and in some cases crumbling. Exuberant granulations spring up around the opening made by the knife in the soft parts, and the peculiar depressed mouth of a sinus leading to dead bone soon begins to make its appearance. With a probe, a tract of bare bone corresponding to the region around the bony meatus may be detected. For weeks, no portions of this diseased bone will come away, but at last the nearest edge of the dead tract will appear to rise up, so that a probe may be worked under it, and then gradually, day by day, the dead shell or scale of bone (for it is in many cases the outer wall of the mastoid cells) will be found to be coming out through the sinus. This process is attended with more or less discharge from the ear, but if the sinus behind the ear is kept freely open, the discharge from the auditory canal will be very slight, and hence, granulations are not usually found in the canal in such a case, for the drainage is kept up from behind and away from the auditory meatus. During this process the patient has no pain, the discharge is not very copious, but there will be, from time to time, swelling of the glands in front of and under the ear, and down the tract of the sterno-cleido-mastoid muscle. These swellings are not painful nor very hard. They last for a few days and then usually disappear, though they may suppurate in the worst cases. Perhaps the form of inflammation over the mastoid, just sketched, may be due, primarily, to the inflammation of a gland which has become diseased by the diphtheritic poison.

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[1] Archives of Oph. and Otol., vol. i., No. 2, New York, 1870.

[2] New York Med. Record, March 27, 1875.

[3] Archiv für Ohrenheilkunde, Bd. xix. S. 37, 1882.

[4] Ibid., Bd. xiv. S. 66, 1878.

In badly fed and delicate children the diphtheritic form of otitis externa may pass into the *gangrenous* variety. According to Gruber, otitis gangrænosa is much more likely to occur in children than in adults. Although the external otitis occurring in diphtheritic children may lead to necrosis in and about the tympanum, with exfoliation of large pieces of the posterior wall of the auditory canal, I have never seen such cases assume a truly gangrenous nature.

Causes.—The causes of diffuse otitis may be purely idiopathic or local. The latter variety will be found the most usual, as cold air and cold water, wounds, injuries of all kinds, furuncles in the auditory canal, and various inflammatory processes both within and outside of the ear. The latter diseases attack the auditory canal from their nearness to it, as, for example, acute inflammation of the middle ear, some skin diseases, as eczema of the scalp and auricle, the acute exanthemata, and, in rare instances, pemphigus of the entire surface, may also attack the auditory canal and drum-head, as in a case seen by von Troeltsch.

The improper use of all kinds of ear-picks, aurilaves, hair-pins, and tooth-picks, for scratching the ear or for the too zealous removal of cerumen, are constantly found to have been series may amount to a dozen. Sometimes they appear to merge so fast into one another, that the ease gained by the discharge of one is hardly enjoyed by the victim until the throbbing and burning pain of a new one warns him that he must endure the torment of another. The auricle may become sensitive to the least touch and traction, especially if the abscesses are in the cartilaginous part of the canal, and the patient then cannot endure the ordinary pressure of the affected side of the head on the pillow. But such sensitiveness of the ear is not so likely to occur in this form of otitis externa as in the diffuse form. The severest pain and most distressing symptoms are found when the boil is seated in the unpliable parts of the bony portion of the canal; intense distress, however, may be caused by a boil seated just within the opening of the auditory canal. Usually, the gravity of the pain and febrile symptoms will depend upon the depth of the abscess in the tissues of the auditory canal, as well as upon its proximity to the drum-head. Small superficial abscesses do occur in the meatus without any pain, a sense of discomfort and dulness of hearing having been the only cause of the patient's seeking surgical relief. More than one such case has been seen where the abscess had run its full course and was on the point of discharging without having caused the patient any pain. But, of course, such cases are great exceptions, and are explained by the superficial seat of the inflammation. Hardness of hearing and deafness are prominent symptoms of furuncles in the auditory canal. In some cases the deafness is almost absolute, and the congestion being so great, and extending consecutively even into the cavity of the tympanum, the deafness is the last symptom to disappear. But the patient can be assured of the ultimate return of the hearing in such cases if there has been no organic lesion of the drum-cavity. As such a lesion is a very unlikely occurrence in this disease, there is every hope of the return of the hearing.

Inspection of the auditory canal and membrana tympani is usually very difficult if the disease is advanced and the swelling of the meatus considerable. This difficulty is less likely to occur when the disease is in the cartilaginous part of the ear, for with care it may be gradually stretched by the speculum. When the disease is in the bony portion of the canal, one can usually obtain a view of the drum-head only in the earlier stages of the disease. In such cases, if the abscess is seated near the drum-head, it will be seen that the latter is more or less congested at that point nearest the abscess, and in many cases where the boil is near the periphery of the membrana tympani in its upper half, considerable swelling will be found in the region of the membrana flaccida and the folds of the drum-head. In such cases, at first sight, one may be inclined to diagnosticate the disease as myringitis, but the history of the case, and the comparatively normal condition of the drum-head, excepting at the points of secondary congestion produced by the circumscribed inflammation of the canal, and the greater pain in the latter disease, will make the true diagnosis easy. When the abscess in the bony portion of the canal becomes fully developed, the view of the drum-head will be entirely cut off, and the deafness and tinnitus become great. After the discharge has occurred, the drum-head may be seen as a red, and somewhat sodden membrane, which, however, in a few days, gradually assumes its normal color and outline, and the hearing will be found to be returning.

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As has already been said, the occurrence of a small abscess or boil in the auditory canal, denotes that there is a tendency towards the occurrence of another or several in the same spot. Hence, the constitutional, as well as the local, treatment becomes of the greatest importance. Some observers have asserted that chronic furunculosis of the ear is a symptom of diabetes mellitus. I have observed one case of chronic furunculosis in the meatus, the middle ear being unaffected, in a diabetic woman.

Whatever is employed for the cure of boils, when occurring elsewhere in the body, should most surely be employed when they make their appearance in the auditory canal, for they are not only an evidence of the need of an alterative treatment, but they are intensely painful and interfere with hearing.

At the head of the list of remedies stand iron and quinine, while in some cases iodide of potassium has been found most efficacious in breaking up a tendency to the formation of boils. But there is no specific in this malady, and if one form of treatment does not bring about the desired result, another must be tried, until the disease disappears. Most frequently the best results will be gained from those remedies which improve the

Diffuse Inflammation of the External Auditory Canal.—This disease affects the osseous part of the auditory canal usually, but it may at the same time invade the cartilaginous portion and even spread to parts of the auricle in some cases. The only essential difference between it and the disease treated of in the preceding pages, otitis externa circumscripta, consists in its tendency to diffuse distribution to the entire external ear. It does not always originate in the same layer of the lining of the auditory canal. "A simple erythema of the cutis in the auditory canal may be considered the lightest form of the disease, and a periostitis of the canal may be called the severest form."[1]

Just as the circumscribed inflammation in the auditory canal shows the peculiar tendency to narrow itself down to a very minute and true abscess, the diffuse form of otitis externa shows the peculiarity to spread rapidly to all parts of the external auditory canal.

A pure form of periostitis of the external auditory canal never occurs, for the disease is never confined to the periosteum, but from the outset, all the neighboring layers of the wall of the canal are attacked. This is due to the fact that the skin of the canal is more firmly united to the periosteum than the periosteum is to the bone. Hence, an inflammation of the cutis readily extends to the periosteum and the bone, this being most probably the usual course of the disease. There is also a consecutive form of external otitis found in cases of acute otitis media. This always begins at the fundus of the canal.

Symptoms.—The subjective symptoms of diffuse external otitis are more severe in the primary than in the consecutive form.

In the former instance, pain, tinnitus, and deafness are the prominent and very distressing symptoms. Itching in the meatus is a constant, but frequently disregarded, symptom of the approach of this disease.

In general the subjective symptoms do not differ greatly from those of the circumscribed external otitis. In the so-called diphtheritic form the pain is said to be intense, continuing without any interruption day and night until the inflammatory product has assumed another character. The deafness and tinnitus in diffuse external otitis are more marked and more obstinate than in the circumscribed otitis.

The consecutive variety of diffuse inflammation of the external ear is, as a rule, less painful than the primary variety. This feature is most marked when the inflammation of the external ear is consecutive to purulent inflammation of the middle ear.

The *objective* symptoms of diffuse external otitis vary with the position, cause, and grade of the inflammation, being more severe however, a much more frequent attendant of this disease of the auditory canal, than the mastoid redness and tenderness.

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[1] Gruber, op. cit., p. 334.

The discharge of the products of inflammation in this disease may occur from several points, but usually it comes from one only. In the former instance the disease manifests symptoms similar to those of circumscribed external otitis, whereas, in the latter instance, the symptoms are peculiar to a true diffuse external otitis. In such a case, the discharge is remarkably copious, beginning as a discharge of colorless or bloody serum, and terminating in the course of a few days in a less copious purulent discharge. The amount of odorless bloody serum at the beginning of the discharge is so abundant in some cases, as to require the constant holding of a handkerchief to the ear, in order to protect the bedding or the clothing of the sufferer, and thus several handkerchiefs, in the course of the day, may be soaked with the discharge. The most marked instance of a flow of this kind the author has ever seen, was from the ear of a Japanese naval officer, from whom the discharge was very red as well as very copious, so red, indeed, that the patient considered it blood. It continued three days, and was succeeded by a light-yellowish discharge of purulent matter, exfoliation of epidermis from the fundus of the auditory canal and drum-head, with perforation of the latter by external erosion in the postero-inferior quadrant on the eleventh day. The brief mention of this case leads naturally to the statement that many cases of this disease, when situate in the bony portion of the canal, are attended with exfoliation of large pieces of epidermis and perforation of the drum-head from *without* inward. Perforation of the drum-head does not occur frequently as a result of the ordinary course of the disease, but great caution in the use of the syringe should be observed at the stage of exfoliation, for fear of penetrating the drum-head by the force of the stream of water. The swelling and exfoliation of the soft parts of the canal may be so great as to increase the pain and distress of the patient by a further distention of the canal, and the renewed irritation of the diseased part may reproduce considerable fever, which, however, subsides as soon as the exfoliated matter and discharge are removed.

Where it is impossible to gain a view of the drum-head on account of the narrowing of the auditory canal, resort may be had to the catheter, the use of Politzer's bag, or Valsalva's method of inflation, in order to ascertain the condition of the Eustachian tube and middle ear. This is often of the greatest moment, not only in children in whom it is often difficult to make a perfect diagnosis in this disease, but also in adults, in order to determine whether or not the external otitis exists alone or is accompanied by deeper and more serious disease in

granulations spring up around the opening made by the knife in the soft parts, and the peculiar depressed mouth of a sinus leading to dead bone soon begins to make its appearance. With a probe, a tract of bare bone corresponding to the region around the bony meatus may be detected. For weeks, no portions of this diseased bone will come away, but at last the nearest edge of the dead tract will appear to rise up, so that a probe may be worked under it, and then gradually, day by day, the dead shell or scale of bone (for it is in many cases the outer wall of the mastoid cells) will be found to be coming out through the sinus. This process is attended with more or less discharge from the ear, but if the sinus behind the ear is kept freely open, the discharge from the auditory canal will be very slight, and hence, granulations are not usually found in the canal in such a case, for the drainage is kept up from behind and away from the auditory meatus. During this process the patient has no pain, the discharge is not very copious, but there will be, from time to time, swelling of the glands in front of and under the ear, and down the tract of the sterno-cleido-mastoid muscle. These swellings are not painful nor very hard. They last for a few days and then usually disappear, though they may suppurate in the worst cases. Perhaps the form of inflammation over the mastoid, just sketched, may be due, primarily, to the inflammation of a gland which has become diseased by the diphtheritic poison.

In badly fed and delicate children the diphtheritic form of otitis externa may pass into the *gangrenous* variety. According to Gruber, otitis gangrænosa is much more likely to occur in children than in adults. Although the external otitis occurring in diphtheritic children may lead to necrosis in and about the tympanum, with exfoliation of large pieces of the posterior wall of the auditory canal, I have never seen such cases assume a truly gangrenous nature.

Causes.—The causes of diffuse otitis may be purely idiopathic or local. The latter variety will be found the most usual, as cold air and cold water, wounds, injuries of all kinds, furuncles in the auditory canal, and various inflammatory processes both within and outside of the ear. The latter diseases attack the auditory canal from their nearness to it, as, for example, acute inflammation of the middle ear, some skin diseases, as eczema of the scalp and auricle, the acute exanthemata, and, in rare instances, pemphigus of the entire surface, may also attack the auditory canal and drum-head, as in a case seen by von Troeltsch.

The improper use of all kinds of ear-picks, aurilaves, hair-pins, and tooth-picks, for scratching the ear or for the too zealous removal of cerumen, are constantly found to have been with a gray film. In the meatus of the right auditory canal there was a circular ulcer with everted edges, which was covered by a dirty grayish-white and adherent pellicle. It was very sensitive to the least touch. I have seen in secondary syphilis, when an erythema was visible upon the forehead and face of the patient, a similar papular and furfuraceous condition of the auditory canal and membrana tympani. Under constitutional treatment the eruption disappeared simultaneously from all the affected parts. I have also seen in several instances cicatrices after ulceration of the canal and membrana tympani in adults who had been the subjects of hereditary syphilis, but an ulceration in the canal the direct result of syphilis I have not seen.

Treatment.—If we are able to begin the treatment of diffuse inflammation of the external auditory canal in the early stages of congestion and pain, the first course to pursue will be to apply heat and moisture under restrictions yet to be laid down. Warm water, as hot as desired by the patient, should be constantly and gently applied to the affected auditory canal by irrigation or by instillation. When warm fluid applications are to be retained in the auditory canal, the best way to accomplish this is for the patient to lie down with the affected ear uppermost, as already stated when discussing the subject of furuncles in the auditory canal, and the fluids should be kept in the ear as long as they are warm and grateful to the sufferer.

To the water thus used may be added various anodynes, preferably, however, laudanum or morphia. Magendie's solution undiluted will be found to be the best anodyne application, because it is the cleanest and most powerful, and, although it should never be resorted to in the undiluted state, unless the pain is very severe, it can be endured in large quantities in the ear, without producing any unpleasant narcotism, even in young children.

It may be used in instillations of five or ten drops, every half-hour, until relief from pain is obtained, in children as young as three years of age, with the best results. I have frequently used it thus, without observing the least narcotism.

The best way to prescribe it is in small quantities, thus:

℞.—Morphiæ sulphatis, gr. iv;
Aquæ,[1] flʒij.—M.
S. Ten drops, warm, in the ear, as required.

Or, five drops of a warm solution of atropia (gr. j–fl℥j. aq.) may be placed in the affected ear, as suggested by Theobald, of Baltimore.

Voltolini insists on the great benefit to be derived from using absolute alcohol as an instillation in this disease, as recommended by Weber-Liel. It is claimed that it aborts the inflammation, and hence allays the pain.[1] It has often seemed to the author that laudanum perhaps owes its anodyne and curative effects to the abortive power of the alcohol in it.

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[1] For water, cherry-laurel water may be substituted.

It is, perhaps, needless to say, that heat and moisture by all forms of solid poultices of carrots, onions, fat pork, oils, etc., will only tend to aggravate the present sufferings of the patient, and almost inevitably leave behind them portions of the poultice, which, by undergoing decay, or becoming rancid, will lay the foundation of other evils, among which the aspergillus will be found playing a prominent part. In fact, most cases of diffuse inflammation of the canal are made worse, and the disease masked before the surgeon sees them, by the various domestic remedies applied in all cases of ear-pain.

With the local treatment by heat and moisture as set forth, the surgeon must combine a constitutional treatment. He must see that the bowels are opened, if there is evidence of costiveness or constipation, dyspeptic symptoms must be combated, and fever allayed. He may then administer a constitutional treatment specifically adapted to this disease in the auditory canal. Pain in this region may best be overcome by the administration of aconite, as this drug seems to have a happy effect in all painful implications of any branch of the fifth nerve. The ext. aconiti may be given in the dose of one-tenth of a grain every two hours, and with it may be given the sulphide of calcium in doses of one-tenth of a grain to adults, every four hours or oftener, if the inflammatory symptoms are severe.[2] Dr. Theobald, of Baltimore, calls attention to the efficacy of the pyrophosphate of soda, in just such cases as the sulphide of calcium is supposed to be useful. "It should be given in doses of ten to twenty grains every two, three, or four hours, according to the urgency of the symptoms."[3] But whatever means we choose, the anodyne, the sudorific, and the alterative form of treatment, both local and constitutional, will render the greatest aid to the surgeon and comfort to the patient.

If, however, in spite of the above treatment, carefully and conscientiously carried out, the swelling in the auditory canal and the pain increase, an incision carried through the soft tissues will be the next best and the promptest means of depletion and abortion of the diffuse inflammation. This, under no circumstances, is to be done blindly or empirically without due illumination and examination of the canal by means of the forehead-mirror and ear-funnel. The eye of the surgeon must learn now to diagnosticate the best spot for the incision, by the elevation and redness, and not by using a probe to find out the tenderest spot for cutting.

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[1] Monatsschr. f. Ohrenh., No. 7, 1877.

[2] Sexton, American Otol. Soc., 1879.

[3] Philada. Med. News, Feb. 1882.

In this form of inflammation of the external ear, leeching has been advised by some authorities. I have not derived much satisfaction, although two or three large leeches in front of the tragus may give temporary relief to the pain. But the external ear and the parts about it, in this affection, are usually so tender that the mechanical irritation of the leech is most distressing. Therefore this mode of depletion becomes of little value in this disease of the canal. An incision is far better, because more quickly done than leeching, and hence far less painful in the end. And being applied directly to the affected region, is much more efficient. Notwithstanding all efforts at aborting the inflammatory process, suppuration may ensue, and a spontaneous discharge from the ear set in.

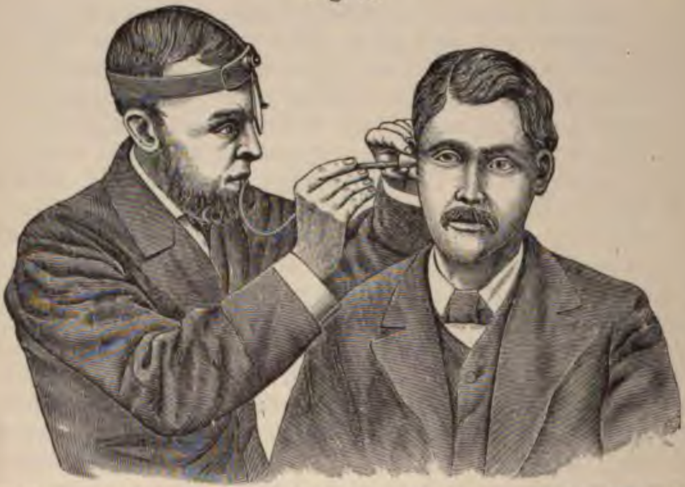
The secretion in the diffuse inflammation of the auditory canal may be very copious, and of a sanious nature. This must be carefully removed, and the ear kept as clean as possible by frequent and gentle syringing with warm water, to which a little castile soap, table salt, or bicarbonate of soda may be added. If the secretion should be tenacious and tend to accumulate in large quantities, and syringing fail to remove it, it should be carefully and gently wiped out with cotton on the cotton-holder. The cotton-holder should never be used by the inexperienced or inexpert hand, as in that case it will prove itself as unworthy an instrument as an aurilave, or sponge tied to a stick, which pushes in much more than it brings out and *never* fails to do harm sooner or later.

As the copious serous discharge, often tinged with blood, diminishes, the running from the ear may assume a yellow color and become thick, but much less in amount. This will be apt to assume a chronic tendency, and the deeper parts of the canal may be found red, disposed to bleed, and roughened into little hillocks. The discharge is so much thicker that it is not easily removed, and excites a tendency to the growth of granulations near the membrana tympani. It becomes, therefore, extremely important to cleanse the ear at this stage and keep down the granulations.

I have found that the principle of aspiration applied to the tumid and sluggish parts will not only cleanse them, but stimulate them into a healthy activity.

After cleaning the ear as thoroughly as possible, by syringing and the cotton-holder, especially in those cases where the dermoid layer of the drum-head has been greatly inflamed, thrown into hillocks, and suppurates freely at several points, I have seen through the Siegle pneumatic speculum, as I have sucked upon the India-rubber tube attached to its side, large drops of pus ooze from the openings in the dermoid layer in quantities sufficient to fill up the fundus of the auditory canal. By this means it is possible to cleanse the inflamed deeper parts much better than by any other means. It is surely the most rapid and perhaps the only immediate way of doing it when pus has accumulated under the dermoid layer of the drum-head or in deeper tissues of the skin of the canal, which enter into the structures of an abscess in the wall of this passage. Whether an abscess be of the nature which forms in circumscribed otitis, or the more diffuse and sluggish kind found at the subsidence of the diffuse form of inflammation of the auditory canal, this method of cleaning out the diseased parts may be used. At the same time that the pus escapes from the sodden parts in such a case as already alluded to, in which aspiration is employed, I have observed that minute drops of blood start out from the excoriated parts everywhere in the canal. This acts as a stimulant to these parts, which do not bleed when touched with the cotton-holder; but their bleeding upon gentle suction with the Siegle speculum reveals their true sluggish nature and will guide in the treatment.

Fig. 79.



Insufflation of Powders into the Ear under Illumination by the Forehead Mirror.

When secretion has been fully established nothing will be found as efficient in checking it, and in preventing the growth of granulations, as insufflation of boric acid, in fine powder, or boric acid in combination with tincture of callendula officinalis (Sexton), or boric acid and oxide of zinc, in equal parts (Theobald), boric acid and chinoline salicylate, one part of the former to sixteen parts of the latter, or boric acid and resorcin, eight parts of the former to one part of the latter. The manner of insufflation under illumination of the external auditory canal is shown in Fig. 79.

The excellence which all the powders named possess as healers of aural inflammation and discharge, while partly due to their drying and detergent qualities, is greatly augmented by their antiseptic and bactericide nature. All powders should be blown gently into the meatus and auditory canal by means of a very simple instrument, which the surgeon can make for himself. Thus, take a foot of good, black or red rubber-tubing, since this kind is more flexible and durable than white, and to one end attach a quill-cylinder made from a goose-quill tooth-pick. This serves to take up the powder and carry it to and into the ear-funnel as far as the inner end of the latter. The ear-funnel should be adjusted first, and the canal viewed by the light reflected from the aurist's forehead-mirror (see p. 161.) Then under this good illumination the quill-end of the blow-tube, in which a little of the medicated powder (about one-third of a quill full) may have been taken up, may be inserted into the ear-funnel, or speculum, as it is generally called in this country. The quill-end-piece must be held as one does a penholder, aim can then be readily taken at the diseased spot, and the gentlest puff from the surgeon's mouth, in which the proximal end of the rubber-tube is held, will send the powder to the diseased surface. All other forms of powder-blowers have the disadvantage of being too large and thus interfering with illumination of the ear during the insufflation, and hence with taking accurate aim and directing the powder just where it is most needed. The method of pouring the powder into the ear-funnel and then into the meatus is wholly inefficient, since most of the powder will cling to the speculum, and none of it can be accurately placed in the diseased ear. That portion of the powder which may get into the meatus by the method of pouring would require ramming to get it in its proper place, and this part of the manipulation becomes an additional labor for the surgeon and disagreeable and painful to the patient. Further, there is always the risk of bruising or abrading the diseased surface in the canal by any form of ramming the powder into its place. It is, therefore, a wholly inconvenient, inaccurate, and dangerous method of applying powders to the ear. It will generally be found that the insufflation of powder in external otitis diffusa will prevent the springing up of granulations, or induce their hasty disappearance. If, however, they should prove exuberant they may be touched with a saturated solution of nitrate of silver, carried to them on a tuft of cotton on the cotton-holder.

If the instillation of a liquid remedy be desired for any good reason in these cases, instead of the dry treatment by insufflation of powders, the following will be found efficient:

℞—Liq. plumbi subacetatis, ♏ xx.
Acid. acetici diluti, ♏ vj.
Liq. opii sedativi, ♏ xx.
Aq. destillat., q. s. f℥j.—M.

The tinctura opii may be substituted in the above prescription for the liq. opii sedativus. Or a one-grain solution of sulphate of zinc, in water, or a solution of borax, or a saturated solution of boric acid may be of value. Ten drops of either of these warmed may be instilled into the ear once or twice daily. If the discharge is copious, the surgeon may syringe the ear once or twice daily. But syringing is, as a rule, never to be entrusted to the patient or his friends. As it tends to induce and promote the growth of granulations, syringing, as well as all other fluid applications to the ear, must be used sparingly, and preferably only by the surgeon. The indiscriminate advice to the patient to syringe his ear and put drops into it has done more to promote ear-disease than to cure it, and hence medical advisers must endeavor to overcome the tendency, growing for many years, to the excessive use of syringing and other modes of applying water to the ear.

If polypi should spring up, with well-defined base or pedicle, they must be extracted by one of the various means described further on, and their attachment to the canal thoroughly touched for several days with a saturated solution of nitrate of silver, or a very minute quantity of chromic acid. In every case where polypi are pulled out, the patient should be told before the extraction that it will be necessary to touch the base of the growth with the acid, or some other caustic, in order to effect a cure.

The treatment just described is that adapted to the ordinary form of otitis externa diffusa with no worse complication than polypoid granulations or polypi; there are, however, several other forms of this disease, as already stated, viz., the diphtheritic, the gangrenous, the syphilitic, and the parasitic.

The treatment will be modified in the first three, by the fact that they are much more painful than the fourth, which, however, causes some pain. As the first three indicate a constitutional alteration and poisoning of the blood, their treatment must be largely of a supporting and alterative nature. Their names will indicate the kind of blood-poisoning they are due to, and their general treatment must be conducted on the principles followed in the same diseases when they manifest themselves elsewhere in the body.

Epithelial Cancer of the Auditory Canal.—Epithelial cancer may attack the tissues in the meatus after first appearing at or near the tragus. The growth at this point may rapidly ulcerate, and advance inward along the canal, with great pain in the ear. The wall of the meatus becomes covered with small, wart-like excrescences, the tissues in the canal become infiltrated and disorganized, and the membrana tympani invaded and perforated. Fistulæ may appear between the mastoid and auricle, and the canal be destroyed, and in its place a large opening may be made by the disease. The articulation of the jaw now becomes exposed, the lymph-glands in the neighborhood infiltrated, and facial paralysis, with exophthalmus and blindness in the eye on the affected side, ensue.[1] Death occurs in the course of a few months from the time of the first ulceration. The treatment can be only palliative.

Otomycosis.—Judging from the literature of the subject and my own experience, animal parasites are found in the external auditory canal much less frequently than fungi. No special name has been suggested for that form of diffuse external otitis excited by the presence in the auditory canal of animal parasites, but for that kind of aural inflammation excited by the growth of fungi in the auditory canal, the general term otomycosis has been suggested by Virchow.

The subject of animal parasites and insects accidentally lodged in the external ear will be considered under the head of foreign bodies in the ear, but I shall consider at this point that form of diffuse external otitis produced by vegetable parasites.

The most common cause of this form of otitis externa diffusa is the growth in the auditory canal of that kind of fungus called Aspergillus. Its two chief varieties are A. nigricans and A. flavescens, the former of which is found in the ear much more frequently than the latter. The ascomycete, *i. e.*, the highest form of development of the Aspergillus, is, as we shall see further on, of very rare occurrence in the ear. Other kinds of fungi have been found in the auditory canal of man, viz.: the *Graphium penicilloides*, by Hassenstein and Hallier; the *Ascophora elegans*, by von Troeltsch; the *Tricothecium*, by Schwartze and Steudener; and the *Mucor mucedo seu fuscus*, by Böke.

The Aspergillus is so very much more common in its occurrence in the external ear than any other fungus, that the aural inflammation it produces is named by Wreden, of St. Petersburg, *Myringomycosis aspergillina*, for it has been observed that this vegetable parasite has an especial proclivity to grow upon the membrana tympani.

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[1] Delstanche, fils, Archiv f. Ohrenheilkunde, Bd. xv.

Myringomycosis aspergillina has been most thoroughly described by Wreden,[1] but before his works were published, Mayer[2] and Pacini,[3] Carl Cramer[4] and Schwartze, had described the occurrence of this form of parasitic disease in the external ear. Subsequent to the appearance of Wreden's papers, various authors[5] have given fully detailed accounts of this disease and its successful treatment. In seventy-four cases of the disease observed by Wreden, only two forms of fungi have been found, viz., the A. flavescens, or glaucus, and the A. nigricans, excepting in one solitary case, in which there was found a fungus richly supplied with capsular sporangia or asci, and which, on account of its intense purplish-red color, was called by Wreden the *Otomyces purpureus.* This fungus was examined by Woronin, a distinguished mycologist of St. Petersburg, who pronounced it to be essentially different from the Ascophora of Schenk, which belongs to the Mucorini. Upon further investigation, this proved to be the ascomycete or utricular form of the *Aspergillus nigricans.* Its fertile hyphens were seen to have a double outline under the microscope, and at different places transverse septa, like the fructiferous hyphens in the varieties of Aspergillus which had already been found in the ear. The width of the broadest of them was 0.00572 mm. to 0.00715 mm. in diameter. The double-outlined wall of the fungus was of a bright yellowish-red color, 0.00143 mm. thick. The fruit-end of the hyphen was composed of a comparatively very large, red, round, vesicular sporangium, which consisted of a thick-walled capsule and a number of round spores, which completely filled its cavity. The diameter of the large sporangia was 0.0572 mm. to 0.06435; that of the smaller ones was 0.02145 mm. to 0.0429 mm. The thickness of the capsule wall was 0.00143 mm. to 0.00214 mm. Dr. J. Orne Green[6] has lately published an account of finding in the ear a similar fungus, which he calls *Aspergillus rubens.* Still more recently Dr. Swan M. Burnett,[7] of Washington, has described the occurrence of the *Otomyces purpureus.*

Two forms of Aspergillus have been found in the ear of man, viz.: the A. nigricans and A. glaucus. Some writers allude to an A. flavescens, but this is probably only a darker-colored A. glaucus. Clinically it would be much better to call the A. niger the A. major, and A. glaucus the A. minor, since the former is so much larger than the latter. This difference in size as well as in other ways, is easily seen under the microscope. Macroscopically, there is no distinct and guiding difference in appearance between these two forms of the fungus. The microscope alone can decide which of the two forms we are dealing with, in a diseased ear.

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[1] Die Myringomycosis aspergillina und ihre Bedeutung für das Gehörorgan, 1868; and Myringomycosis aspergillina, 1869–73, according to personal and foreign observations, Archives of Oph. and Otol., iv. i., 1874.

[2] Beobachtungen von Cysten, mit Fadenpilzen aus dem äusseren Gehörgange, Müller's Archiv, 1844, p. 401.

[3] Supra una muffa parasitica nel condotto auditiv esterno, Florence, 1851.

[4] Sterigmatocytis autacustica, a variety of Aspergillus, Vierteljahrschrift d. Naturforsch. Gesellschaft zu Zurich, 1859–60

[5] Schwartze, von Troeltsch, Böke, Politzer, Gruber, Weber-Liel, J. Orne Green, C. J. Blake, Roosa, Bezold, Lucæ, Nölting, Bezold, Theobald, Swan M. Burnett, et al.

[6] Proceedings of Boston Society of Med. Sciences, 1875.

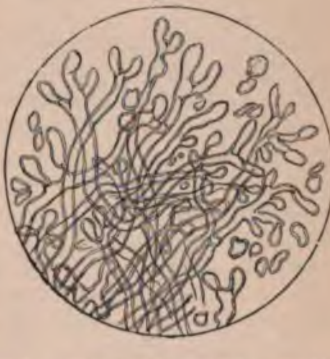
[7] Archives of Otology, vol. x., 1880.

The so-called A nigricans is by far the more common in its occurrence in the ear of man than the A. glaucus, which is rarely found in the ear. I have found it only once in twenty-eight cases.

These forms are easily distinguished from each other by the shape of their fruit-heads and the arrangement of the sterigmata thereon, and on these differences I would like to base their nomenclature. So far as their color is concerned, it is wholly unreliable as a diagnostic difference; in no instance is their color either clearly green or black. In all cases of ordinary aspergillus the color is yellowish or brownish. It has never been shown that one form excites an inflammation different from that produced by the other. For the sake of uniformity and order, I shall retain the names A. nigricans for the *larger*, and A. glaucus for the *smaller* species.

Microscopic Features.—The microscopic features of the growth of this parasite in the human ear are varied and full of interest. If a small piece of a colony of Aspergillus nigricans, in the earliest stages of its development, be examined under the microscope with a power varying from 250 to 300 diameters, a field similar to that in Fig. 80 will be observed. It is, in fact, the first formation of rootlets or the mycelial web, from which, at a later period, the fruit-stalks or fructiferous hyphens spring. It will also be seen that some of the filaments composing the web tend to become bulbous at one end, and that the latter, as the stem grows, becomes larger and dotted (Fig. 81), until finally there is standing out from the dense web of mycelial filaments a perfect fruit-stalk and a fructiferous head—the latter

Fig. 80.[1]



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[1] Figs. 80, 81, and 82 are from original drawings by the author.

studded with short peg-like limbs, the sterigmata, on the free ends of which are the spores. (Fig. 82, B.)

All of these stages of growth I have watched in specimens of the fungus removed from the human ear. In the fluid parts of the specimen, epithelium may usually be seen, in small quantities, as the parasite develops, as in the upper part of Fig. 81.

Very rapidly, in the course of a day or two at most, the perfect fruit-stalk is formed in large numbers and in all stages of development, and the mycelial filaments can be seen to be coarser and septate. On one hand may be seen a well-formed though unripe fruit-stalk and head (Fig. 82, B), while in the centre of the field there may be seen the ripe, aerial fruit, from which the fully grown spores drop literally in myriads. (Fig. 82, C.)

Fig. 81.

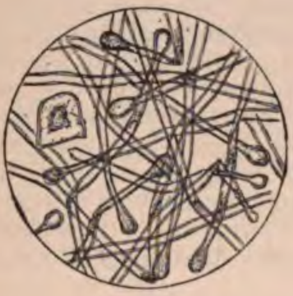
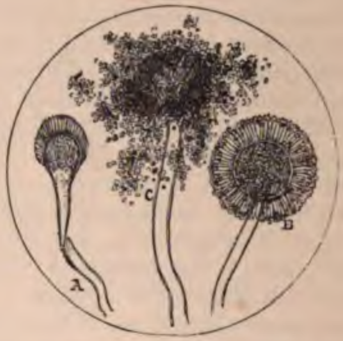


Fig. 82.



The characteristic difference between the two varieties of aspergillus, the so-called *yellow* and *black*, is seen in the shape and size of the *receptaculum*, and the arrangement of the *sterigmata* upon it, these two parts forming the so-called "head" or *sporangium*.

In the *A. nigricans* (Fig. 82, B) the sporangia or heads are distinguished from those of the *A. glaucus* (Fig. 82, A) by the fact that in the first the sterigmata cover the receptaculum, which is spherical, on all sides, while in the latter, the lower fifth or fourth of the receptaculum, which is ovoid in shape, is entirely free from sporangia.

Macroscopic Features.—The macroscopic appearances of a mass of this fungus, as found in or washed from the ear, are worthy of attention. If an ear containing a mass of aspergillus be examined by means of an ear-mirror and ear-funnel, it will present most usually an appearance which leads to the supposition that the ear is occluded not by wax, but by a foreign matter of an organic nature.

If the fungus has not been growing long in the ear, merely a patch of pale yellow, pollen-like matter, of varying diameters, will be detected at the fundus of the auditory canal. This small colony of spores just developing into filaments is usually situate on the membrana tympani, or very near it. In any case, whether the first deposition of spores occurs there or not, the tendency of the aspergillus is to grow over the drum-head first, and from that point it spreads outward covering the wall of the meatus, until a hollow cast of the canal is formed by the vegetable parasite. The pollen-like appearance is seen only in the very earliest stages of a growth of that which is finally a so-called lardaceous-looking or false membrane, either partially or entirely filling the external auditory canal.

In some cases the fungous mass looks like a ball or plug of wet newspaper, and in others the ear may seem to be plugged with a substance looking like wool. An inexperienced eye might conclude that the occluding plug thus formed is of ear-wax; but ear-wax looks more solid, shining, and drier, and it never excites pain and inflammation in the ear like the fungus aspergillus.

Another important point in differential diagnosis is, that a mass of aspergillus does not lose its coherence when subjected to immersion in water or glycerine; but a lump of ordinary hardened ear-wax soon melts, and is diffused through the water or glycerine. Finally, the microscope would reveal the true nature of any mass removed from the ear.

Aspergillus is usually found growing at the fundus of the external auditory canal. It seems to seek the most secluded part of the canal, and hence is most likely to grow first upon the membrana tympani, from which it spreads outward over the entire auditory canal, forming a kind of false membrane in the shape of a glove-finger. This false membrane is composed chiefly of mycelial network, with all forms of aërial fructification of the plant, and some epithelium from the auditory canal. The sporangia are usually found on the surface of the false membrane turned toward the membrana tympani, and the wall of the auditory canal. Although the most perfect forms of growth of the fungus are usually found near the drum-membrane, I have seen specimens so flourishing at the mouth of the auditory canal, that the latter appeared to be sprinkled with bright yellow pollen. In such a case, recently observed, the membrana tympani was not seriously implicated. Usually, however, the membrana tympani and the skin of the canal near it are inflamed by the aspergillus.

An auditory canal which has been the seat of inflammation is most liable to be invaded by the aspergillus. It seems that the remnants of the inflammatory disease, such as pus, dried mucus, epithelial débris or blood, form excellent soil for the growth of the parasite. An active discharge from the ear, however, is unfavorable to the growth of aspergillus in the canal. Aspergillus cannot be in an auditory canal for any length of time without causing the characteristic symptoms of its presence; an exceptional case would seem to be one reported by Moos.[1] The growth of an aural fungus is usually confined to the cutis of the membrana tympani, as shown by Wreden, but, in very rare instances, the parasite may invade the fibrous layer of the drum-head, and finally take root in the cavity of the tympanum, as has been observed by Politzer[2] and others.

Symptoms.—The symptoms of this disease are a sense of fulness, slight pain, burning, itching, tinnitus aurium, and hardness of hearing. The vessels of the malleus become congested, and in a day or two the membrana tympani becomes hidden by a thick, white, false membrane. The slight serous discharge which now sets in, marks the detachment of the false membrane, and the cessation of the pain. In some cases the cutis of the auditory canal becomes deeply inflamed, but not invariably. The pain may become intense if the parasite is not removed. Men are more frequently attacked than women, according to Wreden, who has seen fifty-one of the former, and twenty-three of the latter sex, affected by fungi in the ear.

In twenty-eight cases of this disease which have come under my notice in private, it occurred ten times in women, and eighteen times in men. Both ears were affected in six instances. So far, this disease has never been found in very young children. The oldest patient I have observed with this disease of the ear was a man seventy-seven years old.

The following case, in which a perfect mycelial tube-cast of the auditory canal was removed by the author, will supply all the typical features of an ordinary attack of the disease, and will be seen to agree in the main with the observations of others. The patient was under treatment for so-called chronic catarrh of the middle ears, complicated by ozæna. She stated that for more than a year she had had, from time to time, sudden attacks of pain in the left ear, which lasted for a day or two with more hardness of hearing, and then suddenly ceased, with a slight watery discharge from the affected ear. The hearing then returned to its relatively normal state. When she told me this she was free from pain, and the drum-head and auditory canal were in the condition usually seen in a case of ordinary progressive hardness of hearing, with intact but opaque drum-head.

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[1] Archiv f. Ohrenheilkunde, Bd. ii. p. 155.

[2] Wiener Med. Wochenschrift, 28, 1870.

Within *ten* days from that time she came to me, stating that she had had, two days before, an attack of the pain already described, and that there was still a little discharge from the ear. I examined the ear and found the inner portion of the osseous auditory meatus and the membrana tympani covered with a false membrane looking like wet newspaper. I instantly inferred the presence of a fungus, and removed the false membrane very easily by means of a pair of forceps. The removal of the false membrane caused no pain, nor were the parts beneath it very red and sensitive. There was a slight serous discharge from the ear, a drop of which I examined immediately upon a carefully cleansed slide under the microscope, and found that it contained no pus, but myriads of brownish-yellow spores of the *Aspergillus nigricans* and vibriones.[1]

The tube-cast into which the mycelial false membrane had been moulded, was composed chiefly of thalli, and upon its surface were free spores and tufts of aerial fructification of the *A. nigricans;* throughout the false membrane thus formed were scattered epithelial scales.

The hyphens, or fruit-stalks, were not septate, and their large, bulbous ends, from which the spores rise, were a beautiful golden-yellow color, and resembled, in their general shape and appearance, an ordinary onion-top.

In reference to the etiology of this case, it may be stated that the patient had lived for some time in a very damp house, the cellar of which was "covered with mould," but before she had come to live in that house she had never suffered from any fungus-disease in the ear, as far as she knew.

The chronic disease of the ear may have predisposed the organ to a development of fungi, such a tendency having been found in other cases of chronic aural disease, by Wreden and various observers.

The hearing was impaired only from the onset of the pain until the false membrane was removed. An attempt to remove the false membrane in these cases is usually followed by pain, sometimes bleeding.

Aspergillus not only spreads from the drum-head to the wall of the auditory canal and *vice versâ*, but it perforates the drum-head sometimes, and finds its way into the drum-cavity, as in the case reported by Politzer.[2]

The following case is one of growth of aspergillus in the tympanic cavity: A young lady, 18 years old, applied in the autumn of 1872, to the author, for relief from a slight but constant discharge from the left ear. She stated that the discharge had never been attended by pain, that it was light colored and almost transparent. I found the external auditory canal free from disease of any kind, but the drum-head was destroyed excepting in the region of the tympanic folds; the malleus was still present.

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[1] Pouchet (comptes rendus, 1864, p. 148) has found bacteria and vibriones in a discharge from the ear, attended with itching. Hinton, Questions of Aural Surgery, London, 1874, p. 79.

[2] Ueber pflanzliche Parasiten im Ohre., Wiener Med. Wochenschr., 1870, 28.

It was impossible to find out how long the fungus had been growing in the ear, for when it was first detected by the patient's bringing me a flake, dotted with blackish spots, which she had removed from her ear, there were no subjective symptoms different from those which had been connected with the case for years, according to her statements. In order to allay a little itching in the ear, the patient had thrust a hairpin *into the tympanic cavity*, through the largely perforated membrana tympani, and had pulled out the whitish scale, studded with black spots alluded to. That this specimen was pulled from the tympanic cavity was fully proven by the patient's using a hairpin again and bringing out in my presence more fungi on similar scales, which were instantly examined under the microscope.

The auditory canal was, and had been for months previous, free from all traces of anything of this nature or appearance, for she had been under constant treatment for the chronic discharge, which had obliged her to syringe the ear several times daily.

By the use of instillations of absolute alcohol thrice daily, and syringing the ear with warm water, all traces of the fungi and the discharge disappeared, and the ear remained free from itching and serous discharge for some weeks. Although the patient was living in affluence and perfect hygienic surroundings, the itching and discharge again returned, but all the symptoms were once more relieved by the use of alcohol-instillations in the ear with careful and thorough syringing.

This case I mention as a proof that otomycosis is not necessarily a disease of the external auditory canal, although as a rule it is. In the case just narrated, perhaps we have a very rare exception, unless it can be shown that in many cases a thin serous or sero-purulent discharge from the middle ear, is kept up by the presence of fungi. Perhaps this case began as one of myringomycosis in which the fungus, after destroying the drum-head, excepting in the region of its folds, penetrated into the drum-cavity and flourished there.

Etiology.—Respecting the etiology it may be stated that, previous disease of the ear, especially when limited to the canal, and the use of oleaginous remedies for different aural diseases are the most fruitful causes of this malady.

Otomycosis is said to be much more frequently met among the poor than in the richer classes of any country. My experience is just the reverse. As the climate, and consequently the dwellings, of northern continental Europe are damper and, on account of the cold, kept more closed than in this country, we can account for the fact that this disease appears to be more frequent there than here, and therefore attention has been called most thoroughly to this form of aural disease by writers in Germany and Russia.

Mr. Hinton, of London, has rarely found aspergillus in the ear; but Dr. Cassells, of Glasgow, has met with it frequently in his experience. If search were made more frequently for it, aspergillus would be more frequently found. Previous diseases of the ear, especially those productive of exfoliation of epidermis, and those which have left behind them collections of dried pus or any of the products of inflammation, in the auditory canal, may induce a growth of vegetable saprophytes.

It is now established beyond doubt, especially by the investigations of Bezold,[1] that the use of oil in the ear for pain is one of the most fruitful causes of the growth of fungi in the auditory canal and on the drum-head. Oils and all forms of grease put into the ear are usually forgotten, when the pain is gone for which they were applied. They soon become rancid, and thus favor the growth of vegetable parasites, which finally produce all the well-marked symptoms of otomycosis.

This fact furnishes the strongest argument against the common and senseless use of sweet oil for all ear-diseases. It is entirely useless as a remedy for pain, and worthless as a solvent for inspissated wax; for a little reflection will at once make it apparent that oil will not dissolve the semi-oleaginous ear-wax, but that to soften and detach it we need only a slightly alkaline wash. This is not only more efficient than oil, but cleaner and free from the danger of encouraging the growth of fungi.

It would also be well for physicians to see that salves and ointments, which must be prescribed sometimes for aural maladies and applied to the auditory canal, are thoroughly washed out at last, when all further need of their presence in the canal has ceased.

In some instances, though a pure form of aspergillus may invade the fundus of the auditory canal, a bastard form of aspergillus and penicillium may spring up nearer the meatus. This has been observed by Hallier and Blake.[2]

Treatment.—The treatment of otomycosis of the fundus and walls of the external auditory canal, induced by the growth of aspergillus, consists first in destroying and removing the parasite, and, secondly, in allaying the inflammation which its growth in the ear-canal has caused. The destruction of the parasite is most easily and efficiently accomplished by thoroughly filling the fundus of the canal and all other parts of the external ear, affected by the growth of the fungus, with powdered boric acid, borax, or boric acid in combination with chinoline salicylate (one of the latter to sixteen of the former). Thorough syringing, on the part of the surgeon, will accomplish the removal of all parts of the mycelial false membrane, which may have become detached from the wall of the auditory canal. Those portions of the parasitic growth not spontaneously detached, can generally be loosened or wiped from their seat by means of the gentle use of the cotton-dossil on the cotton-holder, under thorough illumination of the affected parts by the forehead-mirror. The method of application of these, or any powders, to the affected ear is by insufflation, as described on page 261. An ear affected with aspergillus should be seen every day by the surgeon, who alone should syringe it, and thus remove the loosened portions of the membrane. After the ear is thus cleansed, a fresh insufflation should be made of one of the powders named above. This is by far the quickest method of destroying aspergillus in the ear, and of allaying the inflammation it has produced.

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[1] Die Entstehung von Pilzbildung im Ohr. Monatsschr. f. Ohrenh., Juli, 1873.

[2] Dr. C. J. Blake; Parasitic growths in the meatus auditorius externus, Transactions American Otological Society, vol. i. p. 170, 1871.

The substances named as useful powders, owe, doubtless, their virtue to their antiseptic and germicide properties. I have found it useful, after all signs of the growth of the parasitic fungus and inflammation have disappeared, to allow the powder to remain a little while in the ear—it may remain there indefinitely without injury—in order to sterilize thoroughly the previously affected parts.

Until within a year or two, I had always employed as a germicide in these cases alcohol, either pure or diluted with water, in varying quantity, to suit the feelings of the patient. For in many instances, especially when the fungus had grown some time and the tissues had become broken, intense smarting ensued upon applying alcohol, even diluted, to the inflamed skin of the auditory canal. Alcohol is undoubtedly an efficient parasiticide, but it does not act as rapidly as the powders named, it is not as easily applied, nor is its use in the ear free from discomfort to the patient. In some cases, however, when the surgeon cannot see the patient every day, the latter may apply to his ear, once or twice daily, alcohol diluted to a point sufficient to make its application painless. By allowing the alcohol to remain in the ear for some minutes, the patient may thus apply an efficient parasiticide to his ear. This treatment, however, is only supplemental to that by insufflation of one of the germicide powders named. It must be repeated here that the patient is not to be entrusted with syringing his own ear. This is especially important because of the natural tendency of the ear thus affected with the growth of aspergillus, to develop an eczema of the meatus, concha, and pinna. This eczematous tendency is fostered by using the syringe freely, as patients to whom syringing is entrusted are most likely to do. Many other substances have been recommended as efficient parasiticide applications to the ear when invaded by aspergillus. Until lately these have been applied in solution. One of the most soothing is said to be hypochlorite of lime, grs. ij, to water f℥j. This certainly would come next in value to alcohol in the list of fluid applications. But the less dependence placed upon fluid applications to the ear in these cases, the better for the patient. Since the recommendation of Bezold, of Munich, to use powdered boric acid in cases of otorrhœa, this dry form of treatment has been found of greater aid than the fluid form. Theobald, of Baltimore, has used with advantage in these cases, a powder of equal parts of oxide of zinc and boric acid.[1]

The masses of fungus which have collected in the ear—and these may be so great as to extend from the fundus of the auditory canal to the meatus externus—should be removed as quickly as possible. The detached masses are easily extracted from the ear by syringing; the adherent ones can usually be pulled away by gentle traction, or a safer plan would be to go on with the use of the parasiticide until the layers of the fungus are spontaneously detached, when they can be syringed out.

CHAPTER II.

FOREIGN BODIES IN THE EXTERNAL EAR.

ANIMATE as well as inanimate bodies are frequently found in the external ear. The former may become of great surgical importance from the annoyance, inflammation, pain, and deafness which they are very apt to produce, as well as from the fact that they may find their way into the middle ear.

The source of foreign bodies may be either from within or without. Under the first class may be placed: abnormal collections of ear-wax from the ceruminous glands; masses of horny epithelial scales, forming the so-called *Keratosis obturans* of Wreden; and collections of stiff hairs from the tragus and auditory canal; also clotted blood, inspissated aural discharges, scales of dead bone, and, in one sense, many of the new formations in the external ear. But, of these varieties of foreign bodies, only the first three will be considered here; the remainder are discussed elsewhere.

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[1] American Journal of Otology, vol. iii. p. 119, 1881.

Under the second head may be classed all animate or inanimate things small enough to have gotten into the external ear from without.

The manner in which they may get into the ear is extremely varied. Foreign bodies of this class are most frequently found in the ears of children, where they are placed usually in play, by the victim or his companions; or foreign substances may be thrust into the ears of adults and of children by accidental or intentional violence. Animate bodies fly or crawl into the ear of man.

FOREIGN BODIES ORIGINATING IN THE EAR.

Collections of Cerumen in the Ear.—According to Pétrequin, the cerumen consists mainly of fat and combinations of potash and fatty acids in the following proportions: In 100 parts of cerumen are found 10 parts of water, 26 of fat, 38 of soapy combination of potash soluble in alcohol, 14 of a similar combination insoluble in alcohol, and 12 of entirely insoluble organic matter, with traces of chalk and soda.

The name of cerumen is probably a corruption of a word compounded of cera and aurium, the wax of the ear. The word cerumen, however, does not appear in modern Latin dictionaries.

The appearances of an impacted plug of cerumen in the external auditory canal are not very varied. Usually, it is easily recognized, but now and then, especially when the impacted mass is due to slow accretion by the daily pushing in and smoothing down of its layers by the towel or fingers of the patient, it will not be easy for the unpractised eye to recognize the mass at once as one of cerumen, for, in some cases, the impaction has so completely adapted itself to the fundus of the meatus and the drum-head, as to resemble a dark and polished membrana tympani. In many cases such a polished mass of cerumen has been regarded as a somewhat abnormally colored drum-head, and treated as such, the deafness dependent upon the impaction of the wax being attributed to other causes, and in some way connected with the "discolored membrana tympani." Such failures in diagnosis lead to curious results.

It is, indeed, not uncommon to find patients suffering from impaction of cerumen in the auditory canal, being treated for some other aural disease with which they are not affected. Thus, the Eustachian catheter and instillation of nitrate of silver have been applied to relieve the deafness which a proper syringing would have speedily cured.

The mere fact that the drum-head is hidden from sight should be sufficient proof that an abnormal obstruction has occurred in the auditory canal, and this alone ought to be considered as the probable cause of the unpleasant symptoms for which the patient seeks relief. These unfortunate failures in diagnosis are but the natural result of the unwillingness on the part of most medical men to devote any time to the study of diseases of the ear, but they are mistakes which might be prevented if the general medical eye were at all familiar with even the appearances of a normal drum-head and auditory canal. In fact, many an ear might be saved if the physician first consulted, could frankly state to the patient the nature and locality of his aural disease, although he might be unwilling to assume the treatment of it.

The rapidity with which masses of cerumen accumulate in the external auditory canal varies greatly. In some individuals, I have removed second and third obstructive plugs in the course of a few months. In other cases, judging from statements of the patients, the plug must have been accumulating, and giving some annoyance in the form of tinnitus and deafness, for years. As a rule, the deafness caused by a plug of cerumen in the auditory canal is of sudden approach, although the foundation of the offending mass may have been much anterior to the hardness of hearing. In most cases the aggravated deafness comes on suddenly after a bath, or when the patient has a coryza, as in the latter instance the walls of the auditory canal may become a little swollen about the obstructing mass. In the former case, the patient thinks that water has gotten into his ear and is still there. In reality, the mass which has, up to the time of the bath, permitted the sound-waves to pass it, becomes swollen by the water which has gotten into the ear, thus cutting off all approach to the drum-head. In vigorous washing with a cloth, not only the water, but the patient's finger, by pushing the plug further in, may contribute to the onset of the hardness of hearing when a plug of cerumen has formed in the canal.

Etiology of Rapid Formation of Cerumen.—There are many opinions respecting the cause of a rapid and abnormal secretion of cerumen, such as is seen in all grades of life. As the ceruminous glands are really modified perspiratory glands, it is reasonable to suppose that a large amount of cerumen is in some way connected with the perspiration. Large amounts of cerumen are found in the laboring classes, whose perspiratory system is, of course, very active, and I have observed that in persons leading a life of ease, in whom large and rapid masses of ear-wax are sometimes formed, the perspiratory glands in the axilla are unusually active. But I am not prepared to say that whenever the axillary glands are unusually active we are sure to find large amounts of ear-wax in such cases. After certain acute processes in the ear, as, for example, furunculi in the canal, or an otitis media acuta, which has healed rapidly, I have observed a tendency to a rapid formation of normal wax in the ear. This is apparently due to the stimulation of the circulation of the meatus consequent upon the acute inflammatory aural disease.

It is held by some that quinine, which affects the nervous structures of the inner ear, may also have great influence over the circulation of the external and middle ears, and that, therefore, the secretion of cerumen is stimulated by this drug. The amount of cerumen is sometimes increased, after a tonic course of treatment for the general health, in certain cases of deafness, and also after local treatment tending to stimulate the circulation in the auditory canal. The repeated formation of obstructive masses of cerumen in the auditory canal, which appears to be an idiosyncrasy in some cases, is probably, therefore, due to active circulation in the skin of the canal and its wax-glands. Great care must be taken to discriminate between impaction of cerumen and keratosis obturans, a disease to be described hereafter.

When the onset of hardness of hearing in cases of impacted cerumen is rapid, it will usually be found that the mass has formed without the knowledge of the patient, and is in no way due to his endeavors at cleansing the auditory canal.

When the deafness due to impacted cerumen has been coming on slowly for months, sometimes for years, it will usually be found that the patient has been in the very bad habit of swabbing out his ears, most commonly with the rolled-up corner of a towel, and sometimes with that most pernicious and reprehensible implement, a piece of sponge fastened to a stick, and sold by druggists under the high-sounding name of an "aurilave." In these cases the plug will be found well packed in and moulded to the fundus of the auditory canal and drum-head.

Such masses are not very hard to remove, considering the long period of their accumulation; they are usually found to contain large quantities of short fibres of cotton or linen from the towel used in the efforts to cleanse the ear.

Impaction of cerumen by attempts at cleansing the meatus not only occurs among adults, but is found among children, whose over-anxious attendants are constantly swabbing out the meatus of their charges, with a corner of a towel, or with other means.[1]

Such cases may sometimes result in a chronic ulcer of the bony portion of the auditory canal, or in the growth of a large polypus from an ulcerated spot on the wall of the bony canal very near the drum-head.

In these cases of artificially impacted epidermis and cerumen, the foreign mass usually assumes the form of a hollow cast of the auditory canal, or a glove-finger, with a cast of the drum-head on the tip. These cases are usually stubborn, and in some instances threaten the integrity of the bony structure of the auditory canal.

In a case which I saw recently, not only a polypus sprang from the ulcer in the auditory canal, but the drum-head was ulcerated through, and water passed into the pharynx when syringed into the external ear.

The patient, a boy eight years old, was carefully watched over by his nurse, who used daily the so-called aurilave, upon the little patient's ears. The impacted mass of epidermis and cerumen at last excited pain in the ear, and upon removal of the mass, which came out in the glove-finger shape, the skin of the auditory canal was found to have assumed almost the appearance of a mucous membrane. The most ulcerated portion was at the anterior wall near the drum-head, and the latter was perforated largely at the postero-inferior quadrant. The discharge was rather thick and dark-colored, not very copious, somewhat offensive, but the hearing was very little altered. A polypus sprang from the ulcerated spot on the anterior wall of the canal near its union with the membrana tympani.

Treatment.—The treatment of simple impaction of wax in the ear consists in the use of the syringe, as explained already (pp. 170, 171).

Cretaceous Bodies in the External Auditory Canal.—According to Rau[2] cretaceous masses in the auditory canal are the rarest kind of foreign bodies found in the ear. But accounts of such bodies being scattered throughout the works of other writers, they appear not to have been very uncommon. Du Verney and

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[1] Similar conditions of the ear have been observed by Mr. Hinton, of London. See supplement to Toynbee on the Ear, London, 1868, p. 429.

[2] Ohrenheilkunde, pp. 367, 368. The authorities given are, Thom. Bartholini, acta medica et philosoph. Hafniensia: ann. 1671 et 1672, 4 T. I. p 82. L. C. F. Germanni, de miraculis mortuorum libri tres. Dresd. et Lips., 1709, 4 Lib. 3, Tit. 3, Sect. 50, p. 1090. Du Verney, p. 156. C. J. Myller, miscell. nat. cur., Dec. 2, Ann. 6, Obs. 262, p. 326. Collomb, Œuvres Méd. Chirurg., Paris, 1790, p. 304.

Leschevin[1] appear to have had frequent examples of them in their experience, and in Williams's Treatise on the Ear[2] (London, 1840), the statement is found, on the authority of Autenreith, of Tübingen, that "in the bodies of almost all old people there is found, in the innermost part of the meatus auditorius externus, a firmly attached lump of indurated ear-wax, which, in old age, acquires a disposition to crystallize, partly in an earthy form," and also that "Morgagni has found the cerumen of the hardness of stony matter." But these bodies are not frequently met in the present day. I am not aware of any record of such a case in modern literature, nor have I ever met such cases in the many hundreds of ears of old people I have examined in various infirmaries. But, since it is a well-known fact that mineral substances, such as potash, chalk, and soda, enter into the composition of the cerumen, it is not improbable that now and then stone-like bodies are found in the auditory canal, which owe their existence to the mineral elements of the cerumen.

Treatment.—If such bodies should be found in the ear, the treatment of them may be effected as detailed in the general summary at the end of this chapter.

Laminated Epithelial Plug in the External Auditory Canal.—This obstructive disease of the external ear was first described by Wreden,[3] of St. Petersburg, and named by him keratosis obturans, in contradistinction to ceruminosis obturans, the impacted plug of ear-wax, with which it has often been confounded, though differing from it very widely. The latter disease, as its name implies, consists of a mass of inspissated cerumen, but it is easily removed by proper syringing, and the ceruminous nature of the mass removed from the ear is recognized, among other features, by the rapidity with which it dissolves in water.

Keratosis obturans, however, recently described as a separate and special disease of the ear, is a collection of epithelial laminæ, derived from the cutis of the external auditory canal, of gradual accretion, causing great deafness, and very obstinate in its resistance to removal. Every one who has had any extended experience in removing from the ear impacted endogenous masses, usually of cerumen, must have noticed that now and then a peculiar mass is encountered, requiring a *piecemeal* removal by patient, and careful use of syringe and forceps, and which, after lying a long time in water, will not dissolve as ordinary ear-wax does. Wreden having investigated such exceptional masses, and, finding that their composition is not of cerumen but of the horny elements of the cutis, he has proposed for them the name of keratosis obturans. Beneath these masses, in a typical case, the membrana tympani will be found normal in appearance and usually unimpaired in function. The hearing, as a rule, is good after the removal of the mass of epithelium. Not so, however, in the so-called cholesteatomatous masses found in the canal and middle ear.

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[1] Lincke's Sammlung, I. No. 1, p. 29, 1835.

[2] Page 184.

[3] Archives of Oph. and Otol., 1874.

These obstructive bodies are not confined to any age or sex. Upon inspection of an ear containing such a mass as has been described, a thin layer of ordinary cerumen may be seen covering the outer surface of the plug, and hence the impression is often gained that the case is one of ordinary ceruminous impaction. But continued syringing, by its barren results, soon convinces the operator that he has encountered no such ordinary obstruction.

The first case of this disease I had the opportunity of observing occurred in July, 1874, since which time I have seen a number of cases in private as well as in the infirmary. The patient was a banker, sixty years old, suffering from sudden and intense deafness in the occluded ear, with some tinnitus and vertigo. The auditory canal was almost entirely blocked up by the dense, horny mass, with the outer end covered by cerumen. The patient stated that ten years previous he had been liable to attacks of pain in the auricle, especially about the lobe, which were followed by a crop of vesicles and pustules, probably a form of herpes zoster. Since then he has had no pain in or about the ear, but at times he has noticed, without any apparent previous cause, a thin and somewhat offensive discharge. At first sight I thought the case one of impacted cerumen, mingled possibly with inspissated mucus and pus, but the utter failure of the attempts with the syringe to move the impacted mass at the first sitting convinced me that the case was one of those described as keratosis obturans.

Owing to the fact that the auditory meatus was rendered abnormally tortuous by two large exostoses of the canal, one above, the other below, it required patient and careful picking and syringing for half an hour for eight days before all of the foreign body was removed, with, at last, a restitution to normal hearing. From statements of the patient, it appeared probable that similar though smaller and less annoying plugs had been removed from the same ear before, by himself, but he could not give any idea as to the length of time the present one had been forming, as the onset of deafness, the only symptom first attracting his attention to the ear, had been almost instantaneous. This patient had a slight return of the disease, one year after the above attack, but it was entirely removed by soaking the mass repeatedly for twenty-four hours with a solution of bicarbonate of soda, gr. xx, in glycerine and water, āā f℥ss.

Usually in these cases of keratosis in the external ear, part of the mass comes away as a coherent plug, but most of it must be broken down and removed in small pieces. In the case narrated, about half of the mass was removed as a well-defined plug.

When the horny and laminated mass is first washed out of the ear, it is perfectly white, and resembles a set of layers of wet tissue-paper slightly separated from one another by the buoyant effect of the water. When pressed upon, it has the tough, leathery feel of a wad of wet paper, which peculiarity will always distinguish it from the ordinary cerumen-plug of soft and greasy consistence.

As insolubility of such a mass is one of the distinctive features of this peculiar aural disease, a mass may remain as long as five months in glycerine and water without undergoing change. I exhibited such a mass at the Philadelphia Pathological Society, in December, 1874. This specimen, for several months longer, lay in the same preservative fluid, and still there was no dissolution of the mass. Of course, had the mass been formed of ceruminous elements, it would have melted down almost instantly, and distributed itself throughout the fluid. This resistance to solution will readily account for the difficulty of its removal from the ear. The walls of the canal, from which a keratoid mass is removed, are usually ulcerated at some point, sometimes at several places. Granulations of a most sensitive nature may be found near such spots.

Etiology.—No cause has been suggested for the occurrence of this disease of the external ear, and, although among the laminæ composing these masses Wreden has sometimes found vegetable spores, he is not inclined to ascribe the origin of the mass to the irritative presence of a fungus in the auditory canal.

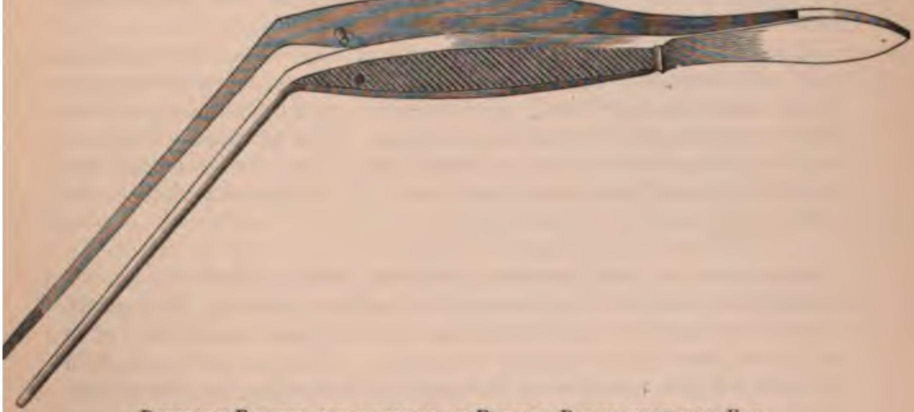
The chronic inflammation and desquamation in the skin of the auditory canal in these cases, may have been set up and favored by the undue efforts at cleansing by the use of a swab, which, unfortunately, some individuals expend upon themselves and upon those under their care. Excoriation is first brought about, and then a slow exudation of dermoid cells goes on, and these desquamated elements of the cells are packed in and mechanically retained in the canal. As the mass of hard epidermis increases in size, it presses on the skin of the canal, and tends to increase the local irritation. So great is the pressure and so sensitive is the inflamed skin, in many cases of this desquamative affection of the ear, that the presence of these laminated plugs is often attended with great and constant neuralgia in the auditory canal, and in front of and behind the auricle, and even over the temple. These plugs are so hard that they retain any discharge which may emanate from the inflamed surface. In this way they further tend to keep up irritation and pain, and to complicate the disease.

Treatment.—In cases showing a decided tendency to recurrence or renewal of these masses in the ear, care in preventing an accumulation of the horny laminæ, by close watching and speedy removal of the slightest amount of scales, will greatly simplify the disease and the treatment.

The solution of soda already mentioned (p. 280) will be the simplest and the best loosener of the plug from the wall of the canal, but sooner or later recourse must be had to forceps and blunt probes. This disease seems to furnish the exception to the rule of treatment, never to use anything more forcible than the stream from the syringe for the removal of foreign bodies from the ear. Of course, the greatest care must be observed in the use of such instruments, and no one but the most experienced surgeon is justified in attempting to remove such a mass by instrumental means.

It is with great caution that I advise their use, and still greater caution that I use them; but as I have resorted to them, and only by their use succeeded in removing the keratosis, I must, in these cases, give their due to such instruments. With perfect illumination of the meatus, proper instruments and cautious movements, added to a thorough knowledge of the use of the implements and the part to be operated on, success must attend their employment.

Fig. 83.



Delicate Forceps for removal of Foreign Bodies from the Ear.

The forceps, represented in Fig. 83, same size as original, is made to open and close very gently, and, being slender, cannot take a very firm hold upon the impacted mass of keratosis, but it is strong enough to pick off and lift away portions of the obstruction. The loss in strength caused by the narrowness of the branches of the instrument is fully compensated in the greater illumination gained by its slender shape, and it is also a much safer instrument than the stronger, thicker, and stiffer forceps usually made for removing foreign bodies from the ear. For removing objects more delicate than masses of keratosis obturans, it is of the greatest value. It is just as necessary to have such a delicate instrument as this to lift things from the ear, as it is to work with delicate and very pliable forceps in manipulating small objects undergoing preparation for microscopic use. In fact most aural instruments are too large. Illumination of the canal is thus too often sacrificed to the strength and size of the instrument.

I fully agree with those who earnestly deprecate the use of any other instrument than a syringe, for the removal of foreign bodies from the ear. The forceps, or any other instrument for removing objects from the ear, must never be tried until all other means have proved of no avail, and then only in the hands of the most experienced and under the most perfect illumination; for any manipulation of the ear resembling a blind grappling after the foreign body will most surely prove disastrous. Unfortunately, the proper occasion for the use of the forceps is almost invariably in an emergency, and is performed by the most inexperienced hands. An examination into the facts of the case, moreover, where they must finally be used, will usually reveal that originally they were not needed, and the simplest syringing at the outset would have rendered the use of any other instrument unnecessary.

The only justifiable use of forceps at the outset may be in a case of keratosis obturans, but even in such cases all instruments must be used with the greatest caution in conjunction with repeated and thorough syringing. The accidents happening to the ear from the ignorant use of instruments for the removal of foreign bodies, have been very numerous and are increasing in number all the time.

Seborrhœa of the External Auditory Canal.—This cutaneous disease is sometimes found in the auditory canal. It usually affects both ears at the same time, and women are more apt to be the subjects of the disease than men. The patients complain of having felt some pain or itching in the ear or ears, which has led them to make various applications to the affected parts, and to scratch the ears with different implements, most usually a pin. This may lead to inflammation and still greater pain. They generally find, sooner or later, that their ears are full of inspissated matter, in crust-like pieces, which they consider dead skin. In consequence of this accumulation there are more or less hardness of hearing and tinnitus aurium. It is for these last-named symptoms that they seek relief. Upon inspection the surgeon finds the auditory canal filled with grayish-white, thick scales, more or less united into a pellicle, clinging to the wall of the canal and extending over the membrana tympani. The calibre of the canal may not be entirely filled with this mass, but the drum-head is covered by it. This obstructive matter can generally be removed by forceps, and, owing to its tough coherence, it may be got from the ear in a rough cast of the canal and the drum-membrane. The hollow of this cast is dry, but the surface, which has been lying against the cutaneous lining of the osseous part of the canal, will be humid. This humidity is not due to pus, but rather to a semi-fluid sebum. The wall of the canal against which this seborrhœic mass has been lying is found to be red, tumid, and sensitive to the touch, and sometimes granulations, or even polypoid exuberances of the latter, are present. This disease is very frequently mistaken for eczema, but eczema rarely attacks the canal. If it is found in the canal, it will be seen that the auricle is also eczematous. In the disease under consideration, however, the auricle is entirely unaffected. These seborrhœic masses form very rapidly, often in the space of a week, after the disease is fully developed.

Treatment.—The seborrhœic masses must be carefully removed and the tumid and diseased surface of the skin of the canal treated. At the same time the general health, which is often found depraved, must be invigorated. The administration of Fowler's solution will greatly facilitate the cure of the skin disease in the ear. The local treatment should consist in the application to the diseased skin of an ointment containing the ammoniated mercury gr. x to vaseline ℥j, or hydrarg. ox. rubri gr. x. to vaseline ℥j. This may be put into the ear by means of a hair-pencil by the patient, or by a cotton-dossil on the cotton-holder, if applied by the surgeon. Insufflations of boric acid will be of use in this disease, applied by the surgeon from time to time, after the inspissated crusts have been removed, and the diseased surface fully exposed. This treatment must be kept up for several months in some cases, before the cure is effected. The prognosis is always favorable.

Pruritus Auris.—Itching in the auditory meatus may be due to the retention of scales of hard cerumen, but that form is not considered here. A distinct disease, a true pruritus, is here alluded to. This is purely a nervous affection in the skin of the meatus. I have met it most frequently in women at the menopause, or in those affected with asthma. An attack of the latter may be preceded by, or attended with, pruritus in each canal. The itching is usually intense and irresistible. Scratching is usually performed most vigorously by the patients, and the skin abraded. It then becomes a ready growing place for aspergillus. The pruritus, however, may continue to recur after the aspergillus has been entirely destroyed. Dr. Sexton[1] has reported pruritus auris in a man suffering from nervous debility.

Treatment.—I have always been able to allay the itching in these cases by the application of one of the following ointments:

℞—Hydrarg. ox. rubri, gr. j.
Vaseline, ʒj.—M.

Or,

℞—Hydrarg. ox. flav., gr. ij.
Vaseline, ʒj.—M.

Apply a little of either to the affected ear with hair-pencil.

Ingrowing Hairs from the Tragus, resting on the Membrana Tympani.—Sometimes, though rarely, the growth of hair on the tragus may be so copious as to block up the external meatus or pass into the canal and rest upon the drum-head. Such cases have been observed and reported by Dr. Weir,[2] of New York.

In some instances the entire auricle, especially at the helix and tragus, may be the seat of excessive and almost ludicrous pubescence. In such cases of excessive amounts of hair near the auditory canal, loose hairs may get into the auditory passage, or masses of them block it up so as to induce hardness of hearing.

The symptom of single hairs on the drum-head will be a scraping sound heard only by the patient, whenever the jaws are moved. If cerumen aid in the matting of the hair about the external meatus, considerable deafness may be the result.

Treatment.—Epilation may be applied to the hairs on the tragus as a preventive means. If the hairs have led to obstruction in the canal, the foreign mass must be removed on general principles. Solitary hairs resting upon the membrana tympani may be lifted away by the delicate forceps (Fig. 83) under illumination from the forehead-mirror (p. 161).

FOREIGN BODIES FROM WITHOUT.

Inanimate Objects.—From time immemorial children have pretended to place various kinds of seeds, beads, etc., in one ear and bring them out at the other, for the amusement of themselves or their younger and more ignorant companions. The latter are often victimized by attempting to imitate the deeds of the elder children, and succeed only as far as inserting the foreign body. Some time ago, I removed a honey-locust bean from the ear of a negro-boy, thirteen years old. There is every reason to believe the bean had been introduced two years before. The bean was in a perfect state of preservation, and had given no trouble to the boy, who said he had been induced to "put it in his ear, because he had seen the big boys do the same thing, pretending to remove it again through the nose." He had tried the experiment and failed, but, as the inserted bean never gave him any pain, he had never told any one of it, "for fear of parental punishment." While examining the ear for purposes of comparison with another, I discovered the bean, whereupon the boy told the above tale. The bean was finally lifted out by forceps with the greatest ease.

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[1] New York Med. Record, Dec. 22, 1883.

[2] Transactions American Otological Society, 1870, p. 30.

Children are very fond of stroking their faces and various parts of their body with beads or any similar object with a polished surface. It is while thus amusing themselves, by stroking their ears, that beads, etc., often slip into the auditory canal. The variety of such bodies found in the ear is endless, being wads of paper, all kinds of seeds, and small beans, beads, round tips of pencils and penholders, pieces of slate-pencils, and little stones, buttons, etc. Usually the foreign body is placed in the ear by the victim; sometimes it is pushed in there slyly by his playmates. Sometimes during quarrels various long objects, such as straws, pencils, penholders, bodkins, etc., are thrust into the ear maliciously, both among children and adults.

I remember a case in which a woman having a grudge against a man, waited for a chance to box his ear, during the time he scratched his ear with a penholder, such being his custom. The opportunity offered itself, the man received his box on the ear, and the pen-holder, being pushed suddenly into the canal, penetrated the drum-head.

While this could hardly be called a foreign body which remained in the ear any length of time, it serves to show how the ear may be injured by pushing a foreign body into it, or by unskilful endeavors at its removal, which may force it further inward. Foreign bodies often remain some time in the ear of little children without doing harm. If a foreign body is found by chance in the ear of an adult, it will often be found upon inquiry to have been put there during childhood.

I have in my cabinet a specimen illustrative of such a case. It is a blue bead seven mm. in diameter, four mm. in thickness, and perforated at its centre, removed with a mass of inspissated cerumen from the right meatus auditorius externus of a woman sixty-eight years old. The patient was entirely unaware of its presence in her ear, and, of course, could give no account of its mode of getting there. It was in all probability placed there in her childhood and forgotten, as it produced neither pain nor deafness. Later, however, the accumulation of cerumen became so great as to cause deafness, and the removal of the obstructive mass to relieve the deafness led to the discovery of the blue bead.

Upon closer inspection of the bead by the patient, she stated that she could recall having played with just such beads when she was about eight years old, and this being the case, it is fair to presume that the bead had quietly rested in her ear for sixty years, one of the longest periods of retention of a foreign body in the ear on record.

Dr. Ludwig Mayer,[1] in an article on foreign bodies in the ear, mentions four cases in which the foreign substances were in for four years, two for twenty years, one for forty-five, and one for over sixty.

Deleau states that he once removed a small snail-shell from the auditory canal of a woman, who knew nothing of its presence in her ear.[2]

The same author relates having removed from the ear of a boy five years old another shell, after it had caused pain and distress by its presence in the ear for a year.

Marchal[3] extracted a coral bead, with a ragged surface, from the ear of a military officer fifty years old, in whose ear the bead was placed when the patient was fifteen years old.

Some time since I removed, by a few gentle streams from the syringe, a small pearl shirt-button from the ear of a little girl six years old, after I had given her ether. Before she came to me her ear had been very roughly handled by picks and probes, but not *once* syringed. As she had become very nervous about the painful treatment of the ear, I gave her ether, and the ease with which I syringed out the button only served as another proof of the folly of instrumental picking, probing, pulling, etc., to remove a foreign body from the ear. The ear had commenced to discharge when I first saw her, and the canal was greatly swollen, yet the syringing brought away the offending body. But we hardly dare call such a body offending; that term should be applied to the heroic treatment with curettes, etc., to which the unfortunate little victim had been subjected.

All kinds of corrosive and scalding fluids, melted metals, etc., are not only exceedingly painful but threaten the life of the sufferer if poured into the ear. Morrison[4] records a case of death following the instillation of nitric acid into the ear. Rau[1] states that melted lead poured into the ear of a drunken man produced deafness with purulent discharge and paralysis of the corresponding half of the face, and became so firmly imbedded in the ear that as late as seventeen months after this accident the metal could not be removed. A case similar to that reported by Rau recently occurred in St. Mary's Hospital, Philadelphia, during the service of Dr. Schell.

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[1] Monatsschr. f. Ohrenheilkunde, Jahr. IV. No. 1.

[2] Gazette Médicale de Paris, tome ii., 1834, No. 11, pp. 161–163.

[3] Revue Méd. Française et Etrangère, Jan. 1844.

[4] Wilde, page 378.

Within a short time I have seen the evil effects of scalding fluids upon the ear. The case was that of an Irish girl, 20 years old, who had been induced to pour *boiling* oil into her ear for some slight trouble in it. The agony which ensued was intense, and, although the acute symptoms had ceased entirely when I saw her, the drum-head was white and thick, like a piece of heavy paper, and the hearing was destroyed.

It would seem almost superfluous to mention such folly, but the general ignorance respecting the delicacy of the ear demands such recitals as warnings.

A curious and self-inflicted irritation from a foreign body in the ear occurred in the case of a young printer, finally applying for relief at the author's clinic in the Philadelphia Dispensary in 1872. The young man stated that, two weeks previous to his call at the dispensary, he had placed the core of a roasted onion in his ear, for a slight earache. The pain soon ceased and the onion core was forgotten or "supposed to be absorbed" by the patient, until the secondary irritation, discharge, and hardness of hearing caused by its presence in the auditory canal, drew the patient's attention a second time to his ear. Without any further attempt at self-medication, he applied at the dispensary for relief, and, upon examination, I found the auditory canal entirely blocked up by the swollen and rotten remains of the onion core. The walls of the canal were irritated and excoriated, and a horribly stinking discharge poured from the ear, while the mechanical deafness was great. One good syringeful of warm water removed the offending mass, restored the hearing, and revealed the fact that the drum-head, though deeply macerated, was still intact. With the use of an astringent wash for a few days the ear was entirely healed.

Sometimes the foreign matter is entirely harmless of itself, and might remain in the ear indefinitely, without exerting an injurious effect. The efforts at its removal, made by the ignorant, are the true cause of injury to the ear. This is illustrated in the following case:

On the 30th of April, 1872, Mr. E. S., a machinist, 39 years old, consulted me for pain and deafness in the left ear. He stated that three days previous, while crossing a street, a horse had splashed mud in his ear, which at that time was perfectly sound. Upon returning to the shop where he was employed, his ear was examined by some of his comrades, who said they saw "something in the ear," and proceeded to extract the foreign matter with *chips and mechanic's small tools.* This, of course, caused the patient great suffering, for he said "*several little white pebbles were taken out*" (probably ossicles, as there was no trace of them in the ear when I examined him), and great deafness ensued in the thus roughly handled organ. The pain increased, and a large, red, hard tumefaction appeared under the left auricle and extended to the angle of the inferior maxilla. The patient, naturally a very strong and powerfully built man, was very pale, anxious, and bathed in cold sweat when I made the first examination. There was no discharge from the ear at the time he presented himself to me. My large testing-watch, audible at least forty feet, was heard by this man only about two and a half inches. He heard my voice only when I spoke very close to his ear, and this, probably, only by bone-conduction. The tuning-fork, vibrating on the vertex, was heard by the patient very distinctly in the affected ear. Upon inspection I found the meatus in this case uninjured. A small piece of black street-mud was adherent to the antero-superior quadrant of the periphery of the membrana tympani. The membrana tympani was found to have been entirely destroyed, excepting a very narrow peripheral band, and there was not a trace of an ossicle visible, all of these important structures having, without doubt, been torn out by the ignorant endeavors of the man's friends to remove the mud which had been splashed into the ear. The inner wall of the tympanic cavity was fully exposed to view, revealing healthy, pale, shining mucous membrane, slightly abraded on the promontory. By the Valsalvan method of inflation, air passed through the perforation with the characteristic whistle.

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[1] Ohrenheilkunde, § 319, and Med. Chirurg. Zeitung, 1852, No. 39.

Twenty days later I saw the patient again at the dispensary. He had been hard at work ever since the injury, not excepting Sundays. He had entirely neglected to follow any of the simple directions I had given him, viz., to apply three large leeches to the swollen glands near the auricle, and to remain quiet. The pain and tumefaction had disappeared, however, and the patient was ruddy and cheerful once more. No air passed through the perforated drum-head at this visit, and the hearing distance remained permanently unaltered. Upon inspection I found the edges of the perforated membrane adherent to the promontory and inner wall of the tympanum, the former appearing to project into the meatus in consequence of the excessive retraction of the small remnant of the membrana tympani around it.

It is interesting to notice the sudden and great loss of hearing in this case, as showing the comparatively greater importance of the destroyed ossicles than of the perforation and destruction of the drum-head. A simple accidental perforation of the membrana tympani or drum-head, rarely, if ever, causes such a degree of deafness as was found in this case, in which the evulsion of the ossicles must be regarded as the real cause of the great deafness.

The impaction and long retention of foreign bodies in the ears of children may lead to deaf-dumbness, which may be cured by removal of the obstructiôns in the external auditory canals, as was shown in a case observed by Dr. Sara E. Brown,[1] of Boston. In this case, twenty-eight small gravel-stones which had lain in the external auditory canals for seven years were removed, and recovery of the hearing ensued. This child, a lad of sixteen years, was an inmate of a school for feeble-minded children, where he had been placed in consequence of his retarded mental development, following his deafness. After the pebbles were removed, the lad became more intelligent in expression, and he regained the use of his speech, which he had begun to lose at the age of nine years, when he placed the gravel-stones in his ears.

Animate Objects in the Ear.—Usually, insects which are found in the ear have crawled or flown in during the sleeping hours of the patient. Of course, this is most likely to happen to those who sleep upon floors or on the ground. Bakers, who, working at night and becoming very tired, lie down on the floor of the bakery, always infested with roaches, are very apt to be awakened by the presence of a roach in the ear. The peculiar elongated shape of this insect permits it to wedge itself in the auditory canal, which holds it tightly enough to prevent its escape but not to kill it. It, therefore, is apt to make most violent endeavors with its front feet to escape, and in so doing it scratches and scrapes upon the deeper parts of the auditory canal and drum-head. Such movements are productive of great annoyance and pain to the patient, and if the animal is not removed, severe inflammation will be set up. Fleas often find their way into the ear, and by their powerful leaps against the drum-head, which produce a noise said by the patients to resemble thunder, cause intense discomfort to the sufferer.

I examined, in the early part of the summer of 1875, an intelligent man's ear, and found large cicatrices in the membrana tympani, with greatly diminished hearing. The patient stated that in his boyhood, while playing in the fields, the so-called devil's darning-needle or dragon-fly had thrust itself, or its long pencil-like body, apparently accidentally, into his ear. Instantly, great inflammation and pain were set up in the organ, and the hearing-power was ultimately nearly lost.

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[1] Archives of Oph. and Otol., vol. iii. pp. 88–90, 1874.

M. Guérin reported to the Société de Chirurgie the case of a soldier, who had returned from Mexico, suffering from facial neuralgia and other affections, which were relieved upon the escape of an *Ixodes hominis* from the sufferer's ear.[1]

The so-called rose-bug may get into the ears of gardeners or others working among rose-bushes. I removed one such insect from the ear of a lady 80 years old, where it had flown while she was picking some roses.

I syringed, not long since, from the ear of a little boy two years old, a dead fly, which was totally enveloped in a kind of epithelial cyst. The mother of the little patient informed me that a year previous, in the summer-time, the child had been attacked suddenly with pain, as she supposed, in the ear, and that his sufferings were so intense as to produce convulsions. The meatus was entirely occluded by the encysted fly; but upon removal of the foreign mass, the membrana tympani was revealed as perfect, and the hearing became normal.

Dead flies are sometimes syringed from the ears of children afflicted with otorrhœa, to which they are attracted by the odor of the discharge, but in most instances produce no pain or subsequent trouble by their presence in the ear.

In some instances, however, maggots grow in the ear after it has been invaded by flies. Heine[2] and Blake[3] have published accounts of the growth of maggots in the ear, and the latter authority has described minutely the apparatus by which these creatures maintain a hold in, and wound the canal and drum-head. The former writer describes a case of a little girl two years old, the subject of a chronic otorrhœa, who had gone to sleep in the hot sunlight with the diseased and offensive ear exposed to the incursion of the flies, and in consequence thereof maggots had sprung up in the ear. In the course of a few days, fat, white maggots, with heads spotted black, were seen in the fundus of the auditory canal. Oil was poured into the ear, and as each maggot came to the surface of the oily bath, it was seized with forceps, and thus all trouble was removed from the ear.

Heine states that he has never failed to remove maggots and all living creatures from the ear, by means of oil in a very few minutes. But the majority of surgeons have not been so fortunate in the removal of maggots by this means.

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[1] Hinton, op. cit., p. 78.

[2] Lincke's Sammlung, ii. p. 181.

[3] Living Larvæ in the Human Ear. Archives of Oph. and Otol., vol. ii. No. 2.

The pain excited by the presence of maggots in the ear is intense, and drives the sufferer to frenzy and even into convulsions. They are usually found in ears previously affected with a more or less offensive otorrhœa, though in a case related by Dr. Kuntzmann,[1] the ear attacked by the larvæ was entirely healthy before invaded by the fly which deposited the noxious egg. The pain attending the presence of maggots in the ear is easily explained by the investigations of Kuntzmann and Blake.[2]

The latter authority placed the larvæ in a glass vessel containing a piece of raw meat soaked in warm water, and then observed the movements and actions of the larvæ under the microscope. He found that the apparatus by which the maggot makes and retains his hold is composed of a delicate horny framework, armed with two hooks, of a stout horny nature, articulating with the aforesaid framework. By a repeated extension and retraction of the hooks, the animal pierces and tears the softest and deepest tissues it can lay hold upon. Hence it is found always in the fundus of the auditory canal and sometimes in the tympanic cavity.

Treatment.—From the investigations of Blake and others it appears, that, since maggots retain such firm hold upon the structures of the ear, after they once get in there, syringing and instillations of fluids which would not injure the ear are insufficient to kill and dislodge such creatures. Blake, Gruber, and others are of the opinion that nothing short of actually seizing the maggots with suitable forceps, and pulling them out, will satisfactorily remove them from the ear.

Sometimes maggots do not appear willing to seize flesh when placed in their way, but burrow immediately in the earth, as stated in Kuntzmann's case, and I have observed that a mass of maggots which were just extruded from a fly showed no tendency to seize some meat which was given them, but, on the contrary, burrowed between it and the sides of a glass vessel containing it and them.

As maggots are extremely hard to kill by any fluid not injurious to the ear, I obtained some for experiment, from a fly, by causing her to extrude her brood of fifty or sixty living creatures about two mm. long. These I placed in a glass vessel with the dead fly and nothing more, and after twenty-four hours found them still alive. I then placed a little piece of cold roast-beef, softened in water, into the glass for the maggots to live upon.

Twenty-four hours later I found them active and grown to be five mm. long, and their alimentary canals stained by the brown juice of the roast meat. In order to try the effects of some easily obtained fluids, innocuous to the ear, upon the maggots, I placed a maggot, No. 1, in a few drops of refined kerosene oil. It crawled repeatedly from the oil and continued to live, though constantly thrust back and kept submerged in the oil. This maggot was finally killed in another way.

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[1] Hufeland's Journal der praktischen Medicin, August, 1824, S. 108–11. Lincke's Sammlung ii. p. 178.

[2] Archives of Oph. and Otol., ii. No. 2.

Maggot No. 2 I placed in a saturated solution of salicylic acid (bleached, prepared by Hance Bros. & White, of Philadelphia). This one died in half an hour.

No. 3 I placed in alcohol, and it died in from five to ten minutes.

No. 4 I placed in ether fortior (Squibb), and killed it by this means in two minutes.

Nos. 5, 6, and 7 I placed in chloroform, and they were instantly killed.

Dr. Roosa has found chloroform vapor, as well as Labarraque's solution of chlorinated soda, fatal to the life of these creatures.[1]

An eighth specimen I placed in hydrant water, which seems, as has been observed by others, to make them more lively at first, and they continue to live and work their savage hooks for a long time, even in a glass vessel where they can gain no hold. Water appears not to have the slightest effect in arresting their work when they have once gained a hold in the soft, moist tissues of the ear. Even after they have been killed by various applications to the ear, the forceps may be required to detach them, so firm is their hold.

Calomel sprinkled over them has been said to kill maggots in the ear; also solutions of tannin have effected their destruction. Hydrocyanic acid, in the form of infusion made of cherry leaves, is said by Lucæ to destroy maggots in the ear.[2]

Foreign Bodies in the Eustachian Tube and Middle Ear.—In Mayer's article[3] on foreign bodies in the organ of hearing, we learn that three were found in the Eustachian tube.

One of these bodies, a barley-corn,[4] was found imbedded in the bony portion of the tube, but projected as far as the faucial end. The other two were lying in the wide faucial end of the Eustachian tube.

The imbedded barley corn was found at a post-mortem, the cause of death not given. Bougies not uncommonly break and leave portions behind them in the Eustachian tube. When the bougies are armed with cotton, feathers,[1] hairs, etc., this is more likely to occur. In two cases, recited by Mayer, laminaria bougies broke off, and remnants were left in the Eustachian tube. Urbantschitsch observed a case in which a piece of oak-leaf passed from the mouth through the Eustachian tube and the middle ear, and finally passed through the membrana tympani into the external ear.[2]

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[1] Treatise on Diseases of the Ear, p. 166.

[2] Archiv f. Ohrenheilkunde, Bd. xvii. p. 219, 1881.

[3] Monatsschrift f. Ohrenheilkunde, Jahrg. IV., No. 1.

[4] Prof. Fleischmann's Case. Hufeland's and Ossan's Journal, June, 1835, pp. 25-28.

In some instances a foreign body in the external ear is rudely pushed at last, by endeavors at its extraction, into the middle ear. One of the most interesting of such cases is given by Deleau, Jr.[3] It is that of a little boy, who placed a small gravel-stone in his ear, in play with his comrades. The unskilful and painful endeavors with a curette to remove the body, in conjunction with the struggles of the boy, ruptured the drum-head, pushed the gravel-stone into the tympanic cavity, produced hemorrhage and inflammation of the ear, temporary paralysis of the corresponding side of the face, and excessive photophobia in the eye of the paralyzed side.

This happened while the boy was still in the provincial town where the accident occurred. He was brought to Paris, two weeks later, and Deleau examined the ear carefully, found the pebble seated in the cavity of the tympanum, with its only visible facet in the same plane with the drum-head. By gently touching the body it was found firmly grasped by the swollen mucous membrane of the middle ear, and being so near the chain of bones all traction upon the pebble was deemed highly improper.

Deleau, therefore, introduced a firmly fitting catheter into the Eustachian tube. The third injection of water through this instrument threw the offending pebble into the concha. The otitis in this case soon disappeared, but there is no positive statement as to the condition of the hearing.

Among the rare instances of this occurrence, is one observed by Moos.[4] In this case an unsuccessful endeavor had been made by a physician to remove a coffee-bean from the external auditory canal, under chloroform. After unskilful manipulation the bean disappeared from view. Purulent inflammation set in, perforation of the drum-head occurred, the incus exfoliated, and numerous polypi were developed. The latter were removed, and, by syringing, together with antiphlogistic treatment and the use of astringents in the ear, the bean came into view, though it had passed into the tympanum and could not be seen at the first examination, immediately after the removal of the polypoid growths.

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[1] Hecksher of Hamburg. Mayer's Article, loc. cit.

[2] Hospital Gazette, Oct. 4, 1879.

[3] Lincke's Sammlung, i. pp. 153, 157. Gazette Méd. de Paris, 2d series, tome ii., 1834, No. 11, pp. 161, 163.

[4] Archives of Oph. and Otol., vol. iii. pp. 103-107, 1873.

Upon the authority of Itard and Andry, Rau mentions a case in which an ascaris wandered from the alimentary canal, through the pharynx, into the Eustachian tube.

Sudden and powerful coughing in hæmoptysis may force blood through the Eustachian tube into the tympanic cavity, where irritation and pain may be set up in consequence of the foreign matter thus brought in contact with the tympanic mucous membrane.[1]

Treatment; Removal of Foreign Bodies from the Ear.—When a foreign body is said to be in the ear, the surgeon should first satisfy himself that such is really the case before he begins any operation for its removal. Grave errors have occurred from the neglect of the surgeon to assure himself on this point. When it is fully decided that the statement of the patient or his friends is correct, and that a foreign substance is really lodged in the ear, if the latter has not become irritated and swollen by the attempts of others at the removal of the foreign substance, usually a gentle syringing, the patient's head being inclined towards the affected side, that gravity may aid the surgeon's efforts, will bring away the foreign body. In order to carry this out in very young children, already alarmed by the accidental entrance of the foreign body, we may have to resort to etherizing the patient. In any case, when syringing will not remove the foreign substance and the ear is at all inflamed and swollen, nothing more forcible than syringing should be attempted until the local irritation in the ear is allayed. Too often the attempts at removal of a foreign body from the ear are far more injurious than its presence in the ear.

It may be said that all insoluble substances will do no harm to the ear if let alone. They should be removed in order to prevent mechanical obstruction and deafness. But there is no need of haste. If an animate body, like an insect or maggot, be in the ear, the first effort should be to kill it. This is best accomplished with insects by the instillation of oil, preferably sweet oil, into the ear.

After all irritation is allayed, which can often be effected, though the foreign body is still in the ear, syringing may be resorted to, and usually with success, in removing the foreign substance. If this fails, and it appears that other means are demanded for the removal of the impacted foreign body, the greatest care and skill are now needed, in order to avoid injuring the ear. A dead insect can be removed from the ear by means of delicate forceps (p. 281) under good illumination, if syringing fails to remove it. A great many plans for removal of foreign bodies impacted in the ear, have been suggested.

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[1] Eindringen von Blut, in die Paukenhöhle bei Hæmoptoë. Archiv f. Ohrenh., Bd. xi. S. 21. Dr. Küpper.

Voltolini[1] recommends the use of the galvano-cautery for the removal of organic foreign bodies which, by unskilful manipulation, have been forced from the meatus into the tympanic cavity and have become imbedded there. By this means, he has cut up and removed piecemeal a bean which had been pushed through the membrana tympani and pressed into the drum-cavity. A bean cannot be properly cut up, however, until it has been softened by repeated injections of water. Then momentary glowings of the finest silver wire cautery will char the bean, and the offending body can be gradually removed after several repetitions of the operation, on different days. But no one not extraordinarily familiar with diseases of the ear, as well as with the use of the galvano-cautery, should attempt such an operation. Voltolini has very justly said, the most that can be asked of the general practitioner is not that he shall remove a foreign body such as this from the ear, but that he shall recognize its presence and let it alone. It cannot be too often brought to mind that it is not the presence of a foreign body that causes ultimate harm to the patient, but the unskilful endeavors to get it out.

Among the various ways of removing impacted bodies from the external ear, should be mentioned the agglutinative method. It has been recently revived by Dr. Löwenberg,[2] of Paris. This method was fully described by Riverius[3] and Celsus,[4] and is also given by Rau.[5] It consists in smearing with glue or some equally tenacious substance, a piece of linen, cotton cloth, or the like, firmly attached to a handle, which is brought into contact with the foreign body in the ear, and then allowed to remain until perfect adhesion takes place. Then, in most instances, the foreign substance can be lifted out with the above-named instrument. This method was employed in this country, some years ago, by a layman, Mr. Eli Whitney Blake,[6] of Conn., for the purpose of removing a foreign body from the ear of a boy employed in his carriage factory. A somewhat similar method is to apply to the foreign body a piece of adhesive plaster fastened to a string, and then warm the miniature disk by means of a burning-glass. When adhesion has taken place, traction on the string may remove the foreign body attached to the adhesive plaster. This method was suggested by the late Dr. E. H. Clarke, of Boston.

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[1] Ueber fremde Körper in der Paukenhöhle und deren Entfernung. M. f. O., No. 5, 1876.

[2] Berliner Klin. Wochenschr., Nos. 9, 10, 1872.

[3] Opera Med., Francofurti, M.DC.LXXIV., Cap de Surditate, p. 261.

[4] Strasbourg edition, 1806, p. 342.

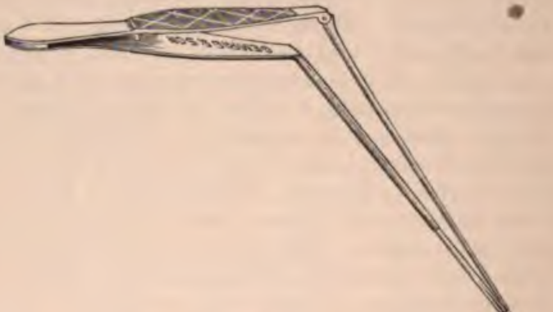
[5] Op. cit., p. 375.

[6] C. Hooker, Boston Journal, 1834.

If syringing fail to remove a foreign body from the ear, and the surgeon is convinced of its impaction in the canal or the tympanic cavity, he may resort to efforts at its removal by means of forceps specially adapted to such cases. For the removal of the laminated plugs of epithelium (p. 278), Dr. E. D. Spear, Jr.,[1] of Boston, has devised a fine-toothed forceps resembling the fixation-forceps of the eyeball.

For the removal of impacted foreign bodies, either organic or inorganic, Dr. Samuel Sexton,[2] of New York, has devised an instrument, represented in Fig. 84. The instrument suggested itself to the mind of its inventor by his army experience in the use of bullet-forceps, with a tooth-like bite. Needle points have been substituted for the teeth of the bullet-forceps, being set at such an angle that when closed against a presenting surface of whatever shape they seize it by the approximation of the two blades in the handle. This is done by pressure of them between the thumb and forefinger, which forces the sliding ring over the blades which are armed with the needle-point teeth. The latter sink into any substance of an organic nature, taking a profound hold on it, and permitting great traction.

Fig. 84.



SEXTON'S FOREIGN-BODY FORCEPS. (Two-thirds natural size.)

Removal of foreign bodies from the ear by incision through the cartilaginous canal from without and behind the auricle was proposed by Paul[3] of Ægina. In the case of an impacted bone pencil-head in the tympanic cavity, Dr. Israel[4] separated the auricle from its posterior attachment to the osseous auditory canal after a crescentic incision behind the ear had been made through the periosteum. The latter with the auricle was drawn forcibly forward, and the foreign body seized and removed through the opening thus formed in the canal. Before Dr. Israel saw this case, unskilful manipulation had driven the foreign body from the external auditory canal into the tympanum. The case then began to manifest very curious nervous phenomena. After the more acute inflammatory symptoms consequent upon the introduction of the foreign body and the endeavors at its extraction had subsided, the patient complained of great pain in both arms, the trunk, and the hips, while the head and ear were free from suffering. Left pupil dilated; fibrillar twitchings in the orbicularis of the left eye and the left levator alæ nasi. Excessive hyperalgesia of the skin in the painful parts of the body, caused the patient to scream when touched.

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[1] American Otological Society, 1880.
[2] American Journal of Otology, vol. ii.
[3] Leschevin; Lincke's Sammlung, I. No. 1, p. 25.
[4] Berliner Klin. Wochenschr., No. 15, 1876; also M. f. O., No. 7, 1876.

On the left side all the symptoms were more pronounced than on the right side. A day later, vomiting and irregular pulse; contraction of the left hand forced the fingers upon the palm; the latter was overcome only by painful and forcible extension. Subcutaneous injections of atropia, $\frac{1}{3}$ mgrm, relieved the contraction, the hyperalgesia, pain, and inequality of the pupils. The hyperalgesia returned, however, and toothache set in. After the removal of the foreign body from the tympanum, all nervous phenomena vanished.

Von Troeltsch[1] gives an account of four successful operations of partial displacement of the auricle for the removal of impacted foreign bodies; one by Langenbeck and three by Schwartze. Dr. J. Orne Green,[2] of Boston, has performed it recently, as have Moldenhauer[3] and A. H. Buck,[4] with success. Green's operation was for the removal of a bullet from the ear of a man, a would-be suicide, forty years old; Moldenhauer's, upon a girl three and a half years old, for the removal of a pebble; and Buck's, upon a boy ten years old, for the removal of a bean. The usual mode of procedure is to make an incision above and behind the auricle in the mastoid region, down to the bone, and lay the auricle and cartilaginous canal forwards toward the cheek, until the insertion of the cartilaginous with the osseous canal is reached and plainly laid open to view. The posterior attachment of the cartilage to the bone is then cut through above and behind, and the foreign body grasped by delicate forceps. Great care must be taken not to sever the cartilage entirely from the bone.

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[1] Lehrbuch, 1881.

[2] American Otol. Society, July 26, 1881.

[3] Archiv f. Ohrenheilkunde, Bd. xviii, S. 59, Nov. 1881.

[4] New York Medical Record, Dec. 16, 1882.

Nicolaysen[1] performed resection of the annulus tympanicus, for the removal of a pebble from the tympanic cavity of a girl four years old. By means of a fine saw, two cuts were made in the anterior and lower portion of the annulus tympanicus 6 mm. apart. The intermediate piece of bone was loosened by a chisel. It was then found to be an easy matter to seize and remove the pebble. There was no inflammatory reaction. The discharge which had been excited by the previous bad treatment ceased. The ossicles had been destroyed.

CHAPTER III.

RESULTS OF INFLAMMATION AND INJURY.

Abscesses in the external auditory canal may lead to an evacuation of their contents through the duct of Steno,[2] or through the cleft found in the posterior superior part of the cartilage of the auditory canal as described by Poorten, after the occurrence of otitis externa.[3]

Caries of the meatus may follow inflammation of the middle ear;[4] in such a case, described by Blake, a portion of the mastoid wall of the osseous meatus, one inch long and half an inch wide, came away. I removed not long ago, an annular sequestrum from the auditory canal of a lady who had long suffered with otorrhœa. It acted like an irritating foreign body. Its removal was followed by recovery.

Mr. Toynbee met with a case of chronic inflammation of the external auditory canal which extended to the bone and brain, producing death.[5] But these are not the commonest results of inflammation in the auditory canal. Those more likely to be met are now about to be described.

Chronic Circumscribed Ulceration in the External Auditory Canal.—Chronic diffuse inflammation of the external auditory canal sometimes ends in the formation of distinct and circumscribed ulceration at one spot in the passage.

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[1] See a notice in Archiv f. Ohrenh., Bd. xx. S. 64, 1883.

[2] Hribar; Wiener Med. Presse, No. 161, 1871.

[3] Monatsschr. f. Ohrenheilk., June, 1872.

[4] C. J. Blake, Trans. Am. Otol. Soc., 1872.

[5] Diseases of the Ear, 1868, p. 73

From this diseased point an inflammatory process may be communicated to the tympanic cavity, and hence ulceration in the external auditory canal becomes of importance. Ulceration on the wall of a patulous auditory canal must not be confounded with those cases of secondary inflammation of the skin of the canal, mentioned by Kramer,[1] "which result from caries of the meatus and of the tympanic cavity, or from destruction of the membrana tympani with disorganization of the investing membrane of the tympanum. In such instances the meatus tumefies, becomes indurated like cartilage, smooth, and dark red; the opening closes up till it will only admit the head of a pin; there is a thin acrid discharge, and on introducing a probe, bare, rough, and carious bone may be felt in the deeper part." The ulcers, especially alluded to here, are found in the unyielding skin of the bony portion of the auditory canal, and by their general features of chronicity and sluggishness remind one of the ordinary leg ulcer. They throw off a scanty, dark-gray or greenish discharge, somewhat offensive, which shows a tendency to form a dark crust around the mouth of the canal.

Sometimes the discharge seems to have ceased, but in a few days it returns again, and, if allowed to run on, the disease will tend to form polypi and to attack the drum-head. The latter becomes congested, all its normal features are lost, and upon syringing the ear, water may pass into the nose and throat. The hearing up to this time may not be much impaired, for the middle ear has remained intact. Upon the occurrence of the perforation, however, the hearing is endangered.

In any case, therefore, where there is found a discharge from the ear with an intact membrana tympani, the most careful search should be made for the cause, and, if an ulcer is found in the bony portion of the external auditory canal, to it the treatment should be directed. These ulcers, if situated in or near the membrana flaccida, may communicate with the upper part of the tympanic cavity.

Itard,[2] when speaking of erysipelatous diseases of the external ear, consequent upon erysipelas of the head, alludes to vesicles which form in the auditory canal, and upon breaking, are converted into true ulcers, which suppurate for a long time.

Others, including N. R. Smith,[3] Williams,[4] Wilde,[5] Rau,[6] Toynbee,[7] and Roosa,[8] allude with more or less distinctness to an ulceration of the meatus, as a separate and chronic form of aural disease.

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[1] Diseases of the Ear, Sydenham Soc., London, 1863.
[2] Maladies de l'Oreille, Paris, 1821, p. 168.
[3] Supplement to translation of Saissy on the Ear, Baltimore, 1829, p. 218.
[4] Treatise on the Ear, London, 1840, p. 116.
[5] Aural Surgery, American edition, Phila., 1853, p. 199.
[6] Lehrbuch d. Ohrenheilkunde, Berlin, 1856, p. 179.
[7] Diseases of the Ear, 1868, pp. 79, 80.
[8] Treatise on Diseases of the Ear, 1873, p. 144

Etiology.—The causes of this disease are often obscure. But it will generally be found that a neglected inflammation in the canal has run at last into the chronic disease here described, or that the ear has been unduly cleaned and abraded.

Treatment.—The treatment should consist in removal of any irritant which keeps up the ulcer, and in stimulation of the inflamed spot. The latter is best accomplished by cauterization by means of strong solutions of nitrate of silver, conveyed to the ulcer by means of cotton on the cotton-holder. Insufflations of boric acid, borax, or borated chinoline (p. 261), or of borated resorcin, will be found of great service in this affection. All discharges are to be most carefully cleaned out by mopping with absorbent cotton or by syringing, and the general health of the patient examined into and built up if necessary. As scrofulous children are liable to be the subjects of this kind of local disease in the ear, iron and cod-liver oil will play a most important part in the treatment of such ulcerations, when occurring in such subjects. The applications of the above local remedies should be effected by the surgeon daily at the outset. The patient's ear should be let alone at home, unless it runs greatly, when it may be mopped out with absorbent cotton. The hearing is not usually affected in the early stages, but it will be, unless the disease is arrested. The prognosis is favorable if the ear is attended to in time.

Reflex Ulceration in the External Auditory Canal.—Reflex neuralgia in the ear, from the irritation of diseased teeth and gums, has been alluded to and explained by the nervous connection existing between the mouth and the ear (pp. 88, 89). It is possible to go a step further and explain reflex tissue-changes in the ear, induced in the same way. At this point only those changes observed in the external auditory canal should be considered. Ulceration in the anterior wall of the auditory canal, near the membrana tympani, may be reflex in origin and maintenance. Such ulceration may be due to decayed molar teeth in the inferior or superior maxilla, on the same side. In these cases the ulceration may be healed by proper treatment, only to break out again and again, after intervals of varying lengths. At the outset there is usually some pain in the ear for a day, then a discharge is observed, the pain having ceased. Examination may reveal a well-marked ulcerated spot on the wall of the auditory canal. This is usually made to heal in a short time, but in the course of a few days, or, may be, even weeks, the same kind of an attack is again felt. In a case like this, a quick and permanent cure was effected after the removal of several diseased molars in the lower jaw of the same side. Such reflex tissue-changes in the auditory canal are evoked in the following way: Let it first be borne in mind that irritation proceeding from any part of the body may excite waves of bloodvessel-dilatation in a correlated area. In the disease under consideration, the seat of irritation is in the teeth and gums, and the correlated area is the external auditory canal. The blood supply to the external auditory canal is derived from the external carotid artery, by its branch, the posterior auricular, and the vaso-motor nerve controlling the calibre of these vessels is derived from the external carotid plexus of the sympathetic. The diseased teeth in the case alluded to were supplied by the inferior dental nerve. Now, the large sensory division of the inferior maxillary nerve, from which the inferior dental nerve comes, is connected on its inner side with the *otic ganglion*. This ganglion is connected with the plexus of the sympathetic, controlling the external carotid artery. As branches of this artery supply the external auditory canal, it is easily seen how this part of the ear becomes an area correlated to the seat of irritation in the diseased teeth, through the medium of the otic ganglion. Since the result of irritation at one point in a vaso-motor tract is to suspend the inhibitory power of vaso-motor nerves in a correlated area, the vaso-motor branches of the carotid plexus, regulating the supply of blood in the external ear, lose, for the time, their power of controlling the calibre of these vessels, on account of the irritation conveyed to them from the teeth through the otic ganglion. Therefore, the vessels in the external auditory canal become distended, and congestion, pain, and inflammation are the result.

Cholesteatomatous-epithelial Impactions in the Auditory Canal.—These cholesteatomatous, epithelial masses are usually found in ears which have been the seat of chronic suppuration, but in which the latter process has apparently run its course. In such cases, the mucous membrane of the middle ear, as well as the cutaneous lining of the external auditory canal, seems to retain a tendency to the exfoliation of large masses of epithelial scales, which, accumulating in the ear, undergo a fatty degeneration and give rise to various symptoms, among which the more prominent are pain at times in the ear (but this is not a prominent characteristic of these formations), nausea and dizziness, with occasional vomiting. The hearing is, of course, impaired by the mechanical hinderance offered by these masses, which may be so large as to cause absorption of the bone of the auditory canal and a consequent widening of this passage. Even greater irritation than this may ensue as a consequence of the presence of such collections in the ear, and the bone structures on which they press may become carious. The soft tissues thus pressed upon ulcerate and become covered with granulations in some instances, and the membrana tympani and ossicles having undergone erosion, the entire tympanic cavity is occupied by the cholesteatomatous layers. The microscope reveals flattened epithelial cells and crystals of cholestearine as the components of these lamellated masses. This process is very analogous to that which produces the keratosis obturans (p. 280).

Treatment.—The treatment of such accumulations should consist first in the complete removal of the obstructive mass. This may require some patience, for the removal of the more external layers often reveals the presence of deeper and fresher ones, and in some cases new ones seem to form during the treatment. The latter tendency is best combated by an alterative astringent, as solutions of nitrate of silver, sulphate of copper, and zinc. I have found insufflations of boric acid and chinoline salicylate (p. 261) to cure these cases promptly. The softening and removal of these masses is hastened by the use of solutions of bicarbonate of soda in glycerine and water.

Sebaceous Tumors, Wens, in the Auditory Canal.—Sebaceous tumors, or wens, are sometimes found in the skin of the cartilaginous part of the external auditory canal. There is very good reason to believe, however, that the surgeon is not usually called upon for assistance in these cases until either the wen has undergone changes in its structure either by erosion or by suppuration, or until it has produced, by pressure or inflammation, organic changes in the cutaneous and osseous structures of the canal. When observed in the early stages of growth, *i. e.*, before any breaking down of its component tissues has occurred, a sebaceous tumor may be seen extending from the anterior wall of the meatus, just within the tragus, entirely across the canal to the opposite wall, thus hiding the drum-head from view. The hearing is impaired in such a case by the mechanical obstruction, and the tinnitus and altered resonance of the patient's voice are very annoying. It is this which first calls the patient's attention to his ear. There is at this stage no pain and no discharge, and the growth may apparently undergo no important change for many years. I have observed one now for six years, which seems to give no increased annoyance. These tumors are soft and compressible, and if a speculum is pushed carefully into the ear thus affected, the tissues in the canal near the fundus will appear macerated and somewhat reddened. The sensibility of the skin of the canal becomes rather blunted than otherwise, at first in these cases. Their occurrence is rare, according to the testimony of Gruber, Rau, and others of large experience. They are analogous to wens of the scalp, and are encysted atheromatous tumors following hypertrophy of a sebaceous gland, the excretory duct of which has become obliterated.[1] Their chief seat being in the scalp may account for the fact that they are sometimes found in the skin of the auditory meatus. These tumors when seated in the scalp may so alter the nutrition of the subjacent parts as to produce destruction of the cellular tissue, depression of the external cranial table, and subsequently erosion of the inner table of the bone, so that the wen may become adherent to the dura mater. This tendency of a wen to cause erosion of the tissues beneath it, is seen in the ear as well as in the scalp, and, doubtless, is the cause of the so-called molluscous tumors in the ear, alluded to by Hinton, Toynbee, and Kirk-Duncanson.[2] Dr. J. Orne Green[3] has observed this disease in the ear, which he terms cystic tumor.

Exostoses of the Auditory Canal.—Exostoses, or bony growths of a rounded, hillock-like shape, are frequently found in the external auditory canal. They are covered by the skin of the canal, are entirely painless, and the only annoyance they give is due to their encroachment upon the calibre of the canal. Their size varies from that of a merely distinguishable elevation on the wall of the canal to that large enough to occlude the canal and produce deafness. The skin covering them is a little paler than that of the canal.

Etiology.—These osseous growths may be congenital, or they may be the result of chronic inflammatory processes in the middle and external ear. They are frequently found in those who have been afflicted for a long time with discharges from the ear, though they are also very often found in those whose ears are otherwise normal.

According to some authorities, exostoses of the meatus in some instances are plainly of a syphilitic origin. They may develop in the auditory canal at the same time with exostoses on other bones, as shown by Gruber, but he does not consider that all such bony growths in the canal have a specific origin. Contrary to the rule in other parts of the body, they are usually painless in the auditory canal. He has described several cases in which hyperplastic growths of the bone of the meatus were associated with a similar affection in the bony portion of the Eustachian tube, without, however, possessing any syphilitic origin.[4] Usually, the causes of exostoses in the auditory canal are obscure, although in many cases Toynbee's theory, that they are due to the rheumatic and gouty diatheses, may be satisfactory. As far as my experience goes, they have been met more frequently in such diatheses than in any others. Mr. G. P. Field[1] believes they could be produced by bathing every day in salt water, which would bring about a chronic inflammation of the walls of the canal.

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[1] Misset; Etude sur la Pathologie des Glandes Sébacées. Paris, 1872

[2] Edinburgh Med. Journal, Nov. 1877.

[3] American Journal of Otology, vol. iii., 1881.

[4] Lehrbuch der Ohrenheilk., pp. 412, 576.

Dr. C. J. Blake[2] has described a peculiarity observed by Prof. Wyman, first in the crania of Hawaiian Islanders, and subsequently in the crania of Peruvians, consisting of exostoses of the external auditory meatus occurring uniformly on the superior and inferior lips of the lamina forming the posterior wall of the passage, the same peculiar growth being described by Welker as occurring in the crania of American Indians. Out of three hundred and thirty-four Peruvian crania examined by Prof. Wyman, these growths were found in six, and in various degrees, from a small pedunculated growth on the superior lip of the lamina to double growths on both lips nearly occluding the orifice of the passage. The supposition that aquatic habits might have to do with the presence of these growths, though applicable in the case of the Hawaiian Islanders, would not apply to the Peruvians, living, as they did, in a tract of country remote from the sea and remarkable for its aridity. That the occurrence of these growths is coincident with the development of the wall of the osseous meatus, as suggested by Dr. J. O. Green, is further supported by the fact that the location of the growth was a constant one. Prof. Turner[3] found exostoses in the auditory canal of a Peruvian skull and also in a Chenook Indian.

The treatment of exostoses in the external auditory canal will be referred to further on.

Osseous Closure of the Auditory Canal.—The consideration of exostoses in the auditory canal leads naturally to the consideration of osseous closure of the canal and the deafness which ensues. Such a closure of the auditory canal may be congenital or acquired. The acquired form appears to be commoner, and this fact should lead to a most careful treatment in those diseases of the ear attended with ulceration and granulations in the external auditory canal. If such growths are found in the auditory canal, great care on the part of the patient should be observed in not picking at or irritating them in any way.

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[1] The Lancet, January 8 and 15, 1881.

[2] Report on the Progress of Otology, 1874. Dr. Blake has since investigated the subject of the occurrence of exostoses in the osseous canal of prehistoric man. In 17 or 18 per cent. of the crania of mound-builders, exostoses were found (*American Journal of Otol.*, vol. ii., 1880).

[3] Journal of Anatomy and Physiology, vol. xii., part 2, p. 200; also American Journal of Otology, vol. i., 1879, p. 229.

Acquired bony closure of the canal has been observed and described by Bonnafont,[1] Dr. L. B.,[2] Mathewson,[3] Jacobson,[4] Theobald,[5] and others. In the cases named, operations for relief of the deafness were performed successfully.

The only case of acquired bony occlusion of the auditory canal, which has come under my notice, presented itself in the right ear of a man fifty-eight years old. At eight years of age the patient was operated on in the Pennsylvania Hospital, for polypus of the left ear. After repeated attempts at extraction of the polypoid growth, which were followed by severe cauterization with solid sulphate of copper, great pain and total loss of hearing, he was removed by his parents from all further treatment. In 1874, about fifty years after the above-named operations, an examination of the ear revealed a shallow meatus, closed at the bottom by ordinary skin. Nothing resembling a drum-head was visible. The skin at the fundus of the shallow auditory canal moved under the Siegle pneumatic speculum. The hearing was reduced to nothing for external sounds. Bone-conduction, however, very good on the occluded side. Tuning-fork on the vertex heard best in the occluded ear. The Eustachian tube was found to be pervious to air by Politzer's method, and the ordinary catheter. The patient, a man ot more than ordinary intelligence, was fully conscious of the entrance of air into his right tympanum, by artificial inflation, as well as whenever he swallowed.

As he was desirous of having an operation on the occluded ear for relief of his deafness, I made an exploratory incision with a paracentesis knife, but found that beneath the skin of the fundus of the canal, there was a bony partition cutting off the external from the middle ear. Considering the age of the patient and the good condition of his left ear, I was unwilling to perforate the bony septum in the auditory canal; but it is probable that such an operation might have been carried out with success in this case.

The pathology of this case most probably consisted in acute inflammation, followed by suppuration, which was allowed to become chronic. Then there ensued a growth of polypi, for the extraction of which, several rough and painful operations were undertaken. Subsequently, the excessive granulation-tissue became organized into a bony septum, covered by a reflection of the normal cutis of the auditory canal.

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[1] L'Union Médicale, May, 1868; also Gazette des Hôpitaux, No. 64, 1867.

[2] Archiv f. Ohrenheilkunde, Bd. x. S. 110

[3] Report of First Congress of International Otological Society, New York, Sept. 1876.

[4] Archiv f. Ohrenh., Bd. xix. S. 34, 1882.

[5] American Otological Society, 1882, p. 46.

"A mass of granulations may become covered with skin or mucous membrane, and its central portions undergo a change into true *osseous* tissue."[1]

Respecting this form, Dr. Buck says "it would be difficult, particularly in this locality, to determine whether a real transition from granulation-tissue to bone takes place, or whether simply the *local* irritation assumes a new phase, the cellular hyperplasia or formation of granulation-tissue ceasing and bone being formed." I am of the opinion that the closure of the canal I have just narrated was caused by a transformation of a mass of granulations into true bony tissue, at a point about half-way down the auditory canal. Since the subcutaneous and submucous tissues of the ear are, at the same time, periosteal coverings, it is reasonable to suppose that such acquired osseous occlusion as has been described cannot be very rare, but often escapes recognition.

Treatment.—Exostoses in the external auditory canal demand no treatment, unless they occlude the canal and cause deafness by this obstruction. Then they may be bored through or cut away, as has been suggested and performed by several operators.

Dr. Mathewson, in the case referred to (p. 305), used successfully the dental lathe as the motive power to turn the drill. The skin is to be removed in these cases before the bone is operated on, and to do this, Dr. Mathewson employed the instrument known among dentists as the scaler. The bony growth was then perforated at several points near its centre, with the smallest of the drills, about one and a half mm. in diameter. This was easily done, and then larger drills, two and a half to three mm. in diameter, were used to widen the opening thus gained in the bony diaphragm. The hemorrhage was not excessive, though there was enough to interfere slightly with the operation. But the auditory canal was kept syringed and swabbed out, so that in half an hour a complete canal to the drum-head was made. The granulations which arose subsequently were combated with nitrate of silver, and, in the course of a few weeks, the drum-head could be seen at the fundus of the canal. The discharge gradually ceased, and the hearing became normal.

Victor Bremer[2] prefers scissors to the dental lathe for the removal of exostoses in the auditory canal, and in some instances he has used chisels for their removal. Moos,[3] in a case of closure of the external auditory canal by exostoses, complicated by acute otitis media, and recurring granulations, employed for the removal of the osseous growth the galvano-cautery, and subsequently kept the canal open by laminaria bougies. Gardiner-Brown[1] employs the dental lathe, as does Mr. Field,[2] for the removal of these bony growths.

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[1] A. H. Buck. "Ultimate forms of granulation-tissue in the ear." Transactions of American Otological Society, 1874.

[2] American Journal of Otology, vol. i. p. 228, 1878.

[3] Archives of Otology, 1879.

As Dr. L. B., of Hamburg, gives an account of an exostosis in his own auditory canal, and the operation on it, by Dr. Knorre, of the same city, the case demands more than a passing notice.

The first symptom of deafness occurred in the patient's forty-third year, in 1868, after a bath. On attempting to pick the ear, to free it from water which was supposed to have lodged there, an obstruction was felt by the patient, which he seized and roughly pulled upon. This caused considerable pain and subsequently inflammation, with diminution of hearing. Upon consulting Dr. Knorre, the obstruction was pronounced by him an exostosis near the membrana tympani. Mild astringent treatment was advised to allay the discharge and inflammation excited by the patient; the hearing then gradually grew better, and four years of undisturbed hearing were enjoyed. In 1873, the hearing began to grow worse, apparently without any exciting cause, but the bony tumor was found to be increasing in size; Dr. Knorre then proceeded to remove the bony obstruction by boring and chiselling. The obstruction was overcome by successively removing parts of it with a drill and chisel, touching the bony growth with hydrochloric and sulphuric acid, burning it with a red-hot knitting needle, and filing down the free surface of it by means of delicate files, smooth on one side, such as are used by jewellers. Most of this treatment was attended with severe pain, so that intervals of rest were rendered necessary on account of the tenderness of the ear. The operations for removal were commenced in June, and by the following January the free surface of the growth had been so much removed as to give a free space between it and the opposite wall of the auditory canal, and the hearing became once more normal. The patient attributed most of the success to the chiselling performed by Dr. Knorre; the other operations were performed by the patient himself.

Other forms of acquired obstruction in the external auditory canal may be partial or total, and they may consist of cutaneous bands, diaphragms of skin or bone, and of horny growths.

Dr. Engelmann, of St. Louis, has described a case in which a bridge-like band of skin stretched across the external auditory canal, from one wall to the other. This, he thought, was probably due to a union of two granular surfaces. Dr. A. H.

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[1] Lancet, March 13, 1880.

[2] Lancet, 1881.

Buck, of New York, has described a similar case.[1] Dr. Roosa[2] found, in a case of chronic suppuration of the middle ear, a cartilaginous band stretched across the outer portion of the canal. Upon division of this band, it was found to contain "scales of bone which seemed to come from the posterior portion of the canal."

Cutaneous Closure of the Auditory Canal.—Cutaneous closure of the canal at any point appears to be more frequent than bony closure. It may be congenital or acquired. This kind of obstruction in the canal is not always recognized at once, especially if the diaphragm of skin is stretched across the canal near the fundus; in such a position, the obstruction may so closely resemble a thickened drum-head as to lead to some confusion in diagnosis.

Dr. Morland[3] has described a case of congenital imperforation of the auditory canal, caused by a cutaneous diaphragm in the cartilaginous portion of the canal, with hyperostosis of the bony portion. In this and in other cases the imperforation was not discovered until disease and deafness in the other ear drew attention to the imperfect hearing in the imperforate ear.

In this case, the external ears were well formed. The occluding cutaneous layer in the auditory canal appeared to be a "perfectly natural and smooth extension, or prolongation from the common covering of the auricle. It was not red nor uneven, nor as if thickened by previous or existing disease; but white and uniform in appearance with the surrounding skin."

After the patient was etherized, a crucial incision of the occluding cutaneous diaphragm was made, and the four resulting flaps were removed with small curved scissors. An aperture, "about as large as a crow-quill," was made, through which a probe was cautiously passed, until it impinged against what was probably the drum-head. The lining of the meatus appeared normal, but there was considerable hyperostosis in the bony portion of the canal. No view of the inner portion of the canal could be obtained. A piece of compressed sponge was then inserted, and subsequently sponge-tents, and the ear cleansed every few days, by the family physician of the patient. By Dr. Morland's advice, a gold tube was also worn in the meatus, and the ear healed in two months, with good hearing.

Acquired Closure.—Dr. A. H. Buck[4] has recorded the case of a young woman, 26 years old, affected with otorrhœa in the right ear in childhood, in whose right auditory canal he found

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[1] Trans. Amer. Otol. Soc., vol. i. p. 536.

[2] Ibid., 1870, p. 90.

[3] Ibid., 1879, pp. 31–34.

[4] Ibid., vol. i. pp. 536, 537.

"a smooth parchment-like membrane of slight but uniform concavity, outwardly." It had a translucent appearance, with no evidence of being provided with vascular supply, and it was tough and decidedly thicker than the membrana tympani. When this was pressed upon by a probe it yielded a crackling sound, audible even to the bystanders. This horny diaphragm was continuous with the skin of the canal at all points.

A free crucial incision was made through this membrane, and it was found to lie about a line on the outer side of the normal plane of the membrana tympani. Through the incision thus made, the red and succulent mucous membrane of the promontory was all that could be seen at first beyond the diaphragm.

As an evidence of the vitality of the false membrane, it is stated that "at the end of the examination a glistening border of bloody serum was noticed along the cut edges of the triangular flaps. At a subsequent visit it was ascertained that the malleus was still present, its tip being adherent to and covered by the tissues of the promontory.

In some cases polypoid growths, invading the same transverse plane of the auditory canal, may grow together, and skin forming over them, a diaphragm is formed, which stubbornly occludes the canal at that point. Beyond the diaphragm the passage may be normal.

Sometimes an orifice is found in the centre of this diaphragm, and by dilatation of this the diaphragm may be reduced to a constriction simply, and then the latter carefully widened.[1]

In such a case the constriction may be overcome by an application of nitric acid, made only once, as in the case of Dr. Buck referred to. I have often seen constriction and funnel-shaped narrowing of the auditory canal following chronic otorrhœa, especially when the discharge had been due to ulceration of hereditary syphilis. I have seen such alterations in the canal of both ears of adults, in whom the discharge had ceased years before. I have also observed granulation-tissue on the walls of the canal unite, and thus form a diaphragm across the canal.

Dr. C. J. Blake[2] has met tumors of a horny nature in the auditory canal. These growths closely resemble the cornua humana. (See p. 220.) Acquired closure of the external auditory canal, either osseous or cutaneous, may arise from otorrhœa in childhood,[3] or from acute inflammation of the canal in childhood,[4] or from the healing of a wound of the auricle and cutaneous external canal.[5] In an instance of the latter kind, Dr. Sexton successfully enlarged a slight sinuous opening in the occluding diaphragm, and cut out a circular piece of the latter one-quarter of an inch in diameter. Then, by dilatation, kept up for some weeks, until healing in the skin of the meatus took place, the hearing was restored.

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[1] See case by Dr. Buck, Transactions American Otolog. Soc., vol. i. p. 538.

[2] Trans. Amer. Otolog. Soc., vol. i. p. 538.

[3] Dr. S. Theobald, American Otol. Society, 1882.

[4] Dr. S. Sexton, American Journal of Otology, vol. iv., 1882.

[5] Ibid.

Partial osseous closure of the canal occurs as the result of chronic purulent discharge from the ear, or from an ostitis set up by improper treatment, or other traumatic causes. In these the narrowing may be so great as to allow only the very fluid discharges to escape, while retaining the more inspissated portions of pus. In February, 1882, I was consulted by a lady 47 years old, regarding pain in her left ear and Eustachian region. She stated that twelve years previous her ear became somewhat diseased, but from the account she gave, its true nature could not be determined. She had been profoundly deaf in that ear ever since. Since the previous December her ear had discharged more, and it had been very offensive in odor. She had had pain in the left eye and left arm, and her neck and left submaxillary region had been stiff and the seat of pain. Vertigo and nausea had been at times very great; she was very pallid, and suffered at times from psychical depression. Examination of the ear revealed a foreign substance, hard and dark, just within the meatus. This was inspissated pus, and upon its removal the osseous canal was found constricted to one-half its normal calibre. When questioned, she stated that her left ear, *i. e.*, her left auditory canal, had once been profoundly cauterized by a physician in the village where she lived with a solid stick of nitrate of silver. This caused great pain and inflammation, and doubtless induced the partial osseous closure of the canal. Syringing the ear by means of the tympanal syringe, the long slender nozzle of which entered easily through the constriction, brought away cheesy and fetid masses, and also caused water and pus to flow into her fauces. Syringing in this way for two days brought away all the cheesy collections in the tympanum, and relieved her entirely of the pain in various parts of her head, neck, and arm. The dizziness and nausea ceased, and her spirits improved. For a week the ear was cleansed daily by syringing and by carefully spooning out any inspissated débris which could be detected, by means of the platinum ring on the probe-like handle (Fig. 57). In the course of a week the red mucous membrane of the tympanic inner wall was seen. There was also a slight tendency to granulations and bleeding. Valsalva's inflation produced very easily the characteristic whistle. The discharge became less, and was further lessened by the use of resorcin wash, ten grains to the fluidounce of water. Insufflation of powders could not be efficiently carried out on account of the constriction of the osseous canal. However, powdered boric acid was carefully conveyed on the cotton-holder into the canal and to the inflamed mucous membrane, and the discharge reduced to a minimum.

Epileptiform Symptoms from Irritation in the Auditory Canal.—It is well known that irritation set up in the auditory canal by the presence of a foreign body will produce epileptiform and even paralytic symptoms. This is amply confirmed by the experience of Fabricius Hildanus, Toynbee, von Troeltsch, Wilde, Handfield Jones, Hillairet, Moos, Urban Pritchard,[1] Raymondaud,[2] Küpper,[3] and others. It, therefore, becomes of the highest importance to examine the ear among other organs in a case of epileptiform disease of doubtful origin. The possibility that the ear or a foreign body in it may have something to do with the case in question should lead every physician to examine this organ or have it examined. It would be but safe to examine the ear as often as the pupil of the eye.

Ear-cough.—Ear-cough, a peculiar reflex cough, excited by irritation of the external auditory canal, was known to medical men a long time ago.

In the celebrated case, given by Fabricius Hildanus (1596), among the various reflex neuroses mentioned as the result of irritation of the external auditory canal by the presence of a glass bead, was a peculiar dry cough.

Tissot[4] wrote of this peculiar cough as generally known in his time, and narrates an instance of it in "a French gentleman who consulted him for total deafness, whose external auditory canal he could not touch, without occasioning a violent cough (toux très forte), which was absolutely uncontrollable." He also states that Etmüller (Francofurti, 1696–97) had observed, that, by touching the external auditory canal with a probe, one could produce a dry cough, which the latter attributed to the "sympathy between the nerves of the ear and those of the trachea."

Pechlin[5] regarded the peculiar cough (ear-cough) arising from irritation of the external auditory canal as a common occurrence, but mentions as a rarity a peculiar reflex sympathy ("consensus") existing between the ear and the stomach (l'ouïe et l'estomac), a striking example of which he observed in a military officer, who vomited considerably whenever his extremely sensitive external auditory canal received the slightest touch even of the finger.

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[1] American Journal of Otology, vol. ii. p. 9, 1880.

[2] Archives Générales de Médicine, Sept. 1882.

[3] Archiv f. Ohrenheilkunde, Bd. xx. 167, 1883.

[4] Traité des Nerfs et de leurs Maladies. Paris et Londres, 1780, pp. 54–56.

[5] Observationum Physicomedicarum Tres libri, Io. Nicol. Pechlini, Hamburgi, anno M.DC.XCI., Lib. 2, obs. 45—quoted by Tissot, op. cit., p. 55.

With the object of ascertaining the percentage of those subject to this sympathetic peculiarity, Dr. Fox, of Scarborough, England, carefully examined one hundred and eight persons: males, thirty-seven; females, forty-five; sex not noted, twenty-six. He concluded that this hyperæsthetic state generally exists in both ears, sometimes, however, only in one, and occurs in about twenty per cent. of those examined.

Ear-cough is due to the fact that the irritation of the auricular branch of the pneumogastric nerve, distributed to the auditory canal, is reflected to the motor fibres of the superior laryngeal nerve, also a branch of the pneumogastric. This induces contraction of the crico-thyroid muscle, which manifests itself as coughing, and, in some instances, vomiting.

Sometimes otitis externa diffusa will also produce the most obstinate ear-cough. The attacks may not be frequent, but they are severe and distressing, not uncommonly ending in vomiting. I have known most obstinate and distressing ear-cough to be excited by the presence in the auditory canals of inspissated cerumen.

Fracture of the Tympanic Bone.—The tympanic bone, which enters largely into the formation of the posterior boundary of the glenoid cavity, as well as into the formation of the anterior wall of the osseous auditory canal, may be fractured by falls or blows upon the chin,[1] or upon the cheek.[2] The hemorrhage from the ear which usually occurs in these cases, has often misled the surgeon at the outset into diagnosticating fracture of the base of the skull. This mistake is all the more likely to be made if the patient is unconscious when first seen. Very often, however, the patient is not unconscious, but complains of pain in his ear, especially upon moving his jaw. The latter symptom, together with the swollen meatus, and the detection of a projection of bone from the anterior wall of the canal, into the calibre of the latter, will enable the surgeon to make the diagnosis of fracture of the tympanic plate. These fractures of the tympanic bone are usually compound, and hence semi-detached parts of the skin of the auditory canal may be seen either projecting into the canal or floating in the blood.

Treatment.—Excessive hemorrhage should be checked in a way not injurious to the drum-membrane. Hence, cold water should not be syringed into the ear. Any portion of bone projecting into the canal, against or through the drum-membrane, should be carefully pushed back to its place, or, if loose, removed from the ear. Healing should be conducted so as not to permit encroachment upon the calibre of the canal. This can be effected by the judicious use of bougies or tents in the canal, until healing has taken place.

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[1] Paul Neis. Thèse pour le Doctorat, Paris, 1879. Buchanan, of Glasgow, in American Journal of Otology, vol. iv. 215, 1882.

[2] Bürkner, Archiv f. Ohrenh., Bd. xviii. S. 300, 1882.

Bleeding from the Meatus.—Hemorrhage from the ear occurs not uncommonly from traumatic causes which apparently produce no further lesion. A physician informed me recently that, slipping suddenly, he struck his mastoid process violently on a projection of some kind in his office. The blow was followed by hemorrhage from the meatus, but by no further trouble. The hemorrhage in such cases comes from a so-called fissure in the skin of the external auditory canal, in its osseous portion. I have recently seen a case in a young woman, who fainted and fell on the floor. A slight hemorrhage came from the ear, and there was in the osseous part of the canal near the drum-membrane a red fissure. These must necessarily occur by contrecoup. Were the force of the blow greater, fracture of the bone underlying the fissure in the skin would probably ensue. Aneurismal tumor in the canal has been observed and described by Dr. C. A. Todd, of St. Louis.[1]

Hemorrhage from the meatus, connected with injuries to deeper parts of the ear, will be considered further on, when alluding to injuries of the internal ear.

Treatment.—If the bleeding is due to an injury limited to the skin of the external canal, a mild styptic may be required. In any event the blood must not be allowed to form permanent clots or crusts in the meatus.

Vicarious Menstruation from the Auditory Canal.—Bleeding from the ear has been observed in some instances of suppressed menstruation. It may be preceded by pain and a sense of fulness in the ear, which however is relieved by the hemorrhage.[2] It may occur from a sebaceous tumor in the meatus, or from the mucous membrane of the middle ear, as in cases observed and fully described by J. Orne Green.[3] In the first case, nose-bleed had once been the mode of vicarious menstruation. This at last gave place to bleeding from the meatus, sufficient at the monthly epoch to cover a handkerchief. The phenomenon was often preceded by severe headache, which was relieved when the bleeding came on. There were no other abnormal symptoms in the ear. Dr. Green made elliptical incisions about the base of the tumor and dissected out the entire mass. The cyst was nourished by a large arterial branch. Five months after the operation there had been neither nasal nor aural vicarious bleeding. Mr. Field[1] has described a case of vicarious menstruation from the right ear of a girl eighteen years old. She had had a purulent discharge from this ear since her sixth year. At about fourteen years of age, she had epistaxis and bleeding from the right ear. Since then she had lost blood from the ear every three weeks. Menstruation by the vagina had never been established. Her breasts were small, and no os uteri could be detected by digital examination.

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[1] American Journal of Otology, vol. iv. p. 187, 1882.

[2] Hinton, Questions of Aural Surgery, p. 97.

[3] American Journal of Otology, vol. iii., 1881.

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[1] Med. Press and Circular, London, Feb. 8, 1882.

SECTION IV.

MEMBRANA TYMPANI.

CHAPTER I.

ACUTE AND CHRONIC INFLAMMATION, INJURIES, AND MORBID GROWTHS.

Acute Myringitis.—In many cases it is of great clinical convenience to speak of an inflammation of the drum-head; but it is not easy to describe, anatomically, such a disease of the ear.

Being so intimate in structural relation with the external auditory canal on one side, and with the tympanum on the other, disease in either of these parts may very easily extend to the drum-head; but as the middle or fibrous layer is the only layer peculiar to the drum-head, and as it has no nervous and vascular supply of its own, it may indeed be said in safety that a true myringitis, implicating the middle layer of the membrane, rarely, if ever, occurs. Nevertheless, it is often observed that an inflammation of the external auditory canal localizes itself in the outer layer of this important partition between the outer and middle ear. Also an inflammation of the mucous membrane of the middle ear may localize itself on the inner surface of the drum-head. Hence, clinically, myringitis may be classed among the diseases of the ear, for the fact is that an inflammation of the skin of the external canal, or of the mucous membrane on the inner surface of the membrana tympani, having culminated in the drum-head, will produce such modifications in that membrane as to demand attention somewhat different from that obtained if the inflammation occurring in these constituent structures had localized itself elsewhere.

As an idiopathic disease, myringitis is of rare occurrence; as a secondary event, very frequent.[1]

Symptoms.—A typical case of so-called myringitis is characterized by pain and tinnitus, but not intense hardness of hearing.

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[1] Gruber, Monatsschr. für Ohrenheilkunde, Nos. 9, 11, and 12, 1875.

Upon inspection it will be seen that the membrana tympani is congested, usually very greatly if the disease has advanced, but that its position is not abnormal, and that the adjacent wall of the auditory canal is little or not at all congested. At the same time the Eustachian tube may be found entirely free, and the membrana tympani will give no evidence by bulging that there is secretion in the tympanum. Hence, then, there may be an inflammation localized in the membrana tympani, the external auditory canal and the middle ear being free from inflammation. It would seem but just, therefore, to give the name of myringitis to such a disease, and mark out for it a special treatment.

By further watching such a case, it will be found that the membrana tympani becomes gradually thicker from infiltration, and at last pus will be found on the outer surface, without the existence of a spontaneous opening in the membrane. By wiping away this product of inflammation, the outer surface of the membrane will be found very red, in some cases almost granular, and it will bleed if touched roughly. This condition of breaking down may go on until an ulcerated spot is at last formed on the outer surface of the drum-head. The latter may lead to a perforation of the membrana tympani, by erosion from without inward. The hearing in the meantime, however, does not suffer as it does when the tympanic cavity is primarily and chiefly affected by disease. As I have assured myself, by means of the catheter and by incisions through the drum-head, that the tympanum is free from disease in all such cases as could be termed myringitis, which I have seen, I am disposed to consider so-called myringitis, an inflammation usually, if not always, of the dermoid layer of the drum-head.

If the mucous surface only of the membrana tympani is inflamed, it is not easy to make such a delicate diagnosis, and, furthermore, there is no proof that inflammation would remain localized on the inner, as it does on the outer surface of the membrana tympani. Doubtless, localized inflammation does occur on the inner surface of the drum-head, but the symptoms it produces are not as distinctive as those produced by inflammation of the dermoid layer.

The symptoms of acute myringitis may be learned from the following case, which will also show the clinical significance of the disease:

A gunsmith, a large, healthy man, 40 years old, complained of some earache, considerable deafness, and marked tinnitus in his left ear, all of which he attributed to exposure to cold air on that side of the head for several hours, while at work. On inspection, the membrana tympani was found reddened, dry, scaly, and somewhat thickened, *i. e.*, it looked more like a piece of thick sheepskin than the delicate normal drum-head. The hearing was found to be $\frac{0}{60}$ in. for small watch. Tuning-fork, on vertex, heard best on affected side. The position of the membrane did not seem altered, but, as the latter looked thick, and as I suspected there might be retained secretion in the tympanum, the membrane was incised; nothing but air came whistling through the cut when Valsalva's inflation was performed. The hearing improved slightly. The perforation healed in a few hours, and the next day the hearing was reduced again to $\frac{0}{60}$ for the watch. The pain, though slight, continued; the membrane looked more swollen; the tinnitus was still annoying. In the course of two or three days, the man presenting himself at the Infirmary, the membrana tympani was found to be covered with a film of pus, beneath which the membrane was quite red. The pain had now become less. Under instillations of zinc and opium, the secretion ceased, the drum-head healed, and the hearing returned, without there having been any symptom of disease, excepting in the dermoid layer of the membrana tympani.

Differential Diagnosis between Acute Myringitis and Acute Otitis Media.—The disease most likely to be confounded with acute myringitis is acute inflammation of the middle ear, but it will be found that there are some very characteristic features by which the one may be distinguished from the other. In acute otitis media there is found, early in the disease, an indrawing of the membrana tympani, without thickening, and the redness is limited to the manubrial plexus and the upper periphery. In acute myringitis, however, the membrane becomes first evenly red all over, rough from partial exfoliation of epithelium, and then thick and infiltrated, but not indrawn; rather flattened than otherwise, or its position remains very nearly normal. The pain in otitis media is intense, while in acute myringitis it is not so terrific. In the former disease, the secretion forms within the tympanum, and there is consequently a marked tendency to perforation of the membrana tympani from within outward. In acute myringitis there is no special tendency to perforation, though there may be such an occurrence in the membrane, by erosion from without inward. Then, further, the secretion in otitis media is copious, and it may be either mucous or purulent. In acute myringitis, however, it is scanty and purulent. In the former, the febrile and constitutional symptoms are severe and often grave, while in acute myringitis such severe symptoms are wanting. These facts, added to others previously mentioned, would seem to warrant a conclusion that there may be, at least clinically, an independent disease, which may be termed acute myringitis. Myringitis may occur in those affected with chronic tuberculosis of the lungs.

Etiology.—The most usual cause of myringitis is sudden exposure of the drum-head to cold. This may occur either from blasts of cold air on the drum-head or from exposure of it to sudden cold in plunging or bathing in cold water. The latter exposure is most commonly incurred at the seaside. The disease may also be caused by instillations of irritating fluids into the auditory canal or by violence from any source. The membrane may be scalded, as in a case observed by Bezold.[1]

Treatment.—The treatment indicated in the acute stage is depletion of the congested membrane. Leeching near the ear will give relief, but a quicker way is scarification of the membrana tympani, as suggested by Dr. Blake. From two to four cuts may be made in each case, the points selected for incision being those of greatest prominence or congestion. Care must be taken not to cut through into the tympanic cavity. Relief is obtained, as a rule, by one scarification. I have practised this form of treatment, with success, in acute cases. Even in the acute stages relief to pain may be given by insufflations of boric acid, or of borax, finely powdered. It has seemed to me that in some cases these insufflations tended to abort the disease. I have also found extremely serviceable the calendulated boric acid, as recommended by Dr. Samuel Sexton,[2] of New York. This powder is prepared by first triturating together equal parts by weight, of tincture of *Calendula officinalis* and finely powdered boric acid. Evaporate the calendula down in a water-bath at a temperature of about 150° F., to a pasty consistence, and then mix with one-half the boric acid; evaporate to dryness, add the other half, and triturate. This strongly calendulated boric acid should then be mixed with twice its weight of pure boric acid, and further triturated, when the surgeon has what is frequently alluded to in this work as *calendulated boric acid.* The original strongly calendulated powder may be mixed with only an equal weight of pure boracic acid, if so desired; but I have employed only that form made of one part of the original strongly calendulated powder and two parts of pure boric acid, which is equivalent to one part of calendula to three parts of boric acid. If, however, secretion is established from the inflamed outer surface of the drum-membrane, the use of these same powders will almost invariably check the discharge, protect the ulcerated surface of the membrane, and promote, by their detergent influence, a ready healing. If a fluid application is required or desired, the following may be used:

℞—Zinci sulphatis, gr. j–ij.
Tinct. opii, f ʒj.
Aquæ, f ʒvij.

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[1] American Journ. Otol., vol. iv. 1882.

[2] New York Med. Record, Dec. 31, 1881.

Of this ten drops, warmed, may be put into the ear, once or twice daily. The ear should be cleansed by absorbent cotton rather than by syringing, since the latter tends to promote granulations. If granulations form, they may be touched by strong solutions of nitrate of silver on the cotton-dossil on the cotton-holder.

Abscess of the Membrana Tympani.—There may be a true abscess of the drum-membrane without perforation of the latter. Two cases are reported by Marian;[1] in one the abscess occurred in the anterior lower quadrant of the membrane, and in the other, above the short process. I have seen two cases of abscess in or on the membrana tympani without perforation of the membrane; once in the membrana flaccida, and once in the postero-superior quadrant implicating the adjacent wall of the auditory canal. In the cases I observed, there was pain. Spontaneous rupture occurred in the first named, and in the latter instance I incised the abscess, with instant relief to the pain. Pain, autophony, and great tinnitus had been annoying the patient for a fortnight before the operation. The membrana tympani was thickened in this case, before the abscess formed, by the habit of excessive bathing and diving in cold sea-water, in which the patient had indulged for many years in summer. In winter-time he was in the habit of putting water into his ears in various ways. This unfortunate habit had produced a gradual thickening of the dermis of the membrana tympani. A myringitis ensuing upon exposure to cold, an abscess formed and was retained beneath the abnormally thick dermis, instead of rapidly ending in the formation and rupture of a vesicle, as is often seen in myringitis from exposure to cold.

CHRONIC INFLAMMATION.

Ulcers in the Dermoid Layer.—As a consequence of acute external otitis or of acute myringitis, ulcers may form on the membrana tympani. As has been stated when alluding to acute myringitis, erosion of the dermoid layer of the drum-head may occur in that disease. The first stage of such erosion would implicate the outer layer, while subsequent advances of the disease would involve the deeper layers. Hence, an ulcer on the drum-head may assume a terraced shape, the upper stratum being the dermoid, the middle the fibrous, and the inner the mucous layer of the membrana tympani.

Most usually, however, the ulcerative process on the drum-head does not pass beyond the two outer layers. That true ulcerative processes do occur here, has been fully shown by J. Orne Green.[1]

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[1] Archiv f. Ohrenh., Bd. xvii. S. 84, 1881.

Symptoms.—Such a process on the drum-head may be attended with some loss of hearing, and usually some tinnitus aurium, but pain is entirely absent. The attention of the patient is called to the ear partly by some hardness of hearing and the subjective noise, but chiefly by the scanty and slow discharge. The scantiness and slowness of the discharge lead to a hardening of it about the meatus, and the ear, feeling dry and stiff, the patient is inclined to pick at it. By such manipulation, dry scales of dark matter are pulled from the meatus, and are usually another incentive to the patient to seek medical aid.

Causes.—This ulceration of the dermoid and other layers of the membrana tympani, I have uniformly found in the poorly nourished classes of the Infirmary. A process in the external ear, especially on the outer surface of the membrana tympani, which otherwise would run an acute course and then disappear, tends to become chronic in the poor and the unclean. In addition to poverty and uncleanliness, there must be added ignorant neglect or improper domestic treatment, the latter consisting chiefly of instilling oils which clog the ear and become rancid, or by the direct instillation of irritants of various kinds. It can be seen how readily all these circumstances tend to provoke, in the cachectic especially, a chronic ulceration in the external ear. For it is a skin disease, a cutaneous ulcer, that is to be contended with in such cases.

Prognosis and Treatment.—The prognosis is favorable if the proper treatment is carried out, but, like every other aural disease, this tends to chronicity in the most favorable circumstances if not properly managed.

Should the condition of the patient demand constitutional remedies (and it always will, according to my observation), some form of iron will be found of great benefit. The syrup of the iodide of iron, or some one of the numerous preparations of iron and cod-liver oil, will render good service in these cases.

The local treatment is of the greatest importance in ulceration of the membrana tympani. The auditory canal must be carefully cleansed by the surgeon by swabbing with absorbent cotton on the cotton-holder, or by syringing with warm water often enough to prevent accumulation of matter. But the secretion in these cases is not usually copious. It is, however, tenacious, and the patient is rarely able to remove it thoroughly by syringing. It is, therefore, of prime importance that the surgeon should wipe off the drum-head and inner end of the canal, by means of absorbent cotton on the cotton-holder. This should be done very carefully and thoroughly, under good illumination of the canal, by means of the forehead-mirror. To attempt to cleanse an ear by swabbing it out, without such illumination, is worse than useless; it is always painful, and most usually injurious.

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[1] Ulceration of the dermoid layer of the membrana tympani. Transactions American Otol. Soc., vol. i. p. 431, 1873.

The perfunctory custom of turning the sufferer's ear towards a window, and blindly forcing into the meatus a probe, armed or unarmed with a tuft of cotton, or a brush, is extremely hazardous. The canal varies enough in every patient to warrant special illumination, by means of ear-funnel and forehead-mirror. By this means the curves in the canal are not struck and wounded, as they are when the canal is manipulated in a less scientific way. After the canal is properly lighted and the membrana tympani perfectly visible, let the latter be wiped off by means of a tuft of cotton on the flexible cotton-holder. When the ulcerated membrane is thus cleansed, the local remedies may be applied. These may consist of insufflations as suggested for myringitis, p. 318, or, in the more chronic stages, of applications of nitrate of silver or of sulphate of copper. Dr. J. O. Green has found the latter very beneficial in ulceration of the dermoid layer of the drum-head. Nitrate of silver is best employed in solution; in these cases it should not be instilled into the ear and allowed to find its way to the fundus of the canal and the drum-head, but it should be applied, by means of cotton on the holder, directly to the diseased spot. Solutions of sulphate of copper may be applied by means of the cotton-holder, or the solid crystal may be used. Dr. Green prefers the latter to the nitrate of silver in any form, in these cases. Neither the cleansing, unless it be by very absorbent cotton, nor the treatment, as a rule, is to be entrusted to the patient in these forms of aural disease, for the reasons already given, that syringing tends to promote granulations, as indeed do instillations of medicinal solutions, heretofore so largely prescribed for the patient's use at home. As insufflations of powders form the best mode of treatment, and as the patient cannot apply them to his ear, nor have it done at home, the treatment naturally falls into the hands of the surgeon.

Perforation of the Membrana Flaccida.—Perforation of Shrapnell's membrane, or the membrana flaccida, appears to be an uncommon occurrence. It is usually found to be the result of chronic disease, either within the tympanic cavity or the external auditory canal, most usually the former, and is generally attended with great hardness of hearing. Most probably the ulcerative process attacking this part of the membrana tympani also greatly implicates the head and neck of the malleus and the body of the incus, and the joint between these two ossicles. I have seen eleven cases of perforation of the membrana flaccida, all of them large, but unassociated with perforations elsewhere in the membrana tympani.

The membrana flaccida, or the flaccid membrane of Shrapnell, may be briefly described as a fan-shaped region, the lower borders of which, or the imagined sticks of the fan, run backward and forward from the short process of the malleus above the upper edge of each so-called fold of the membrana tympani, forming a lower boundary about five mm. long. The upper edge of this important part of the membrana tympani corresponds to that peculiar part of the general periphery of the drum-head known as the segment of Rivinus. The latter is, perhaps, more accurately described as the margo tympanicus, or the inner edge of the upper bony wall of the external auditory canal, and may be looked upon as the osseous complement of the annulus tympanicus, to the innermost and free edge of which the external ligament of the malleus is attached. The membrana flaccida thus outlined is about three mm. high, measuring from the short process up to the point of attachment of the membrane to the upper osseous wall of the auditory canal. This membrane is composed of only two layers, an outer skin layer from the auditory canal and an inner layer of mucous membrane reflected from the tympanic cavity and the inner surface of the margo tympanicus. Directly behind the central part of the membrana flaccida is the neck of the malleus, the head of which lies behind the margo tympanicus. The front part of this membrane is stretched over the anterior upper part of the tympanic cavity, entrance to which at this point is above the so-called anterior pocket of the drum-head. The back part of this membrane, behind the neck of the malleus, is stretched over the front end of a long and shallow groove yet to be described, and at this point the membrana flaccida is about two mm. from the lower part of the body of the incus. This posterior, groove-like cavity is wedge-shaped, bounded on its inner side by the upper part of the body of the incus and its short horizontal process, and on its outer side by the inner surface of the margo tympanicus. The edge of the wedge-shaped groove points downward, and its base opens upward toward the tegmen, while in its long diameter it widens and fades away backward into the tympanic cavity and mastoid antrum. At its anterior end and on its outer side this groove is covered in from the external auditory canal by the back part of the membrana flaccida. Hence, when the membrane gives way at this point, egress is given to matter from the upper and back part of the tympanic cavity, and from the mastoid antrum.

Sometimes a perforation in the membrana flaccida is directly over the short process of the malleus, opening then into what is termed by Prussak and Gustav Brunner, a third pouch of the drum-head. This third pouch is said by the former writer, who first described it, to open into the tympanic cavity at one point only, viz., backward over the position of the posterior pouch of von Troeltsch.

In perforations of the central part of the membrana flaccida, the neck of the malleus is exposed, and in anterior perforations, *i. e.*, in those in front of the neck of the malleus, entrance is effected directly to the large, upper space in the front part of the tympanic cavity, near the tympanic end of the Eustachian tube.

Posterior perforations are usually attended with great discharge, and connected with mastoid symptoms; they are also the most obstinate and accompanied by profound deafness.

Central perforations are most apt to be connected with disease in the external auditory canal, but are least obstinate to treatment, and are not usually attended with such profound hardness of hearing nor so great a discharge.

Anterior perforations are most likely to be connected with pronounced disease in the nares, Eustachian tube, and the tympanic cavity, and to give exit to a copious discharge. But they have seemed to me to be the most remediable.

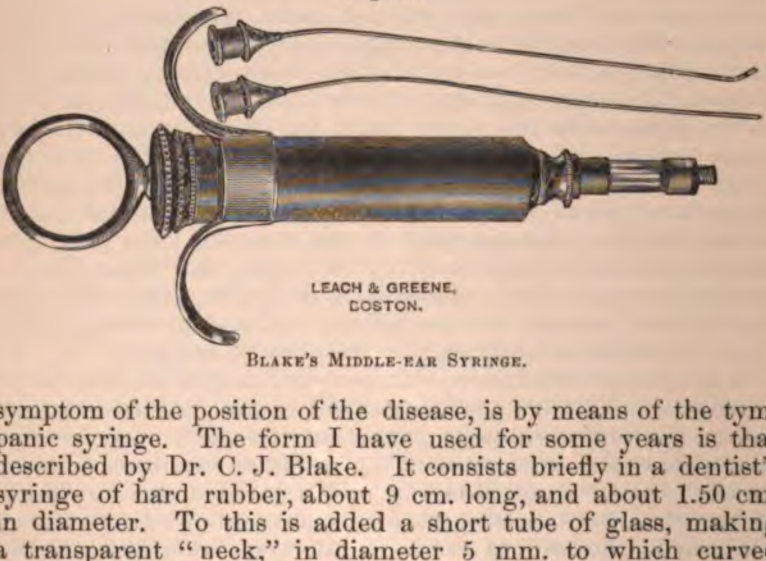
In cases of destruction of the entire membrana flaccida, attended with erosion of the margo tympanicus, there come into view, directly over the line of the folds of the membrana tympani, the neck and head of the malleus, and the junction of the latter with the incus, the body of the incus with the upper part of its descending crus, and the proximal part of its short, horizontal crus. In such cases of extensive destruction the entire dome of the tympanum under the roof can be viewed by turning the patient's head to the opposite side, and there may be seen as well the cavity of the upper and front part of the tympanum, and a dark cavity, in the back part of the space thus opened around the head of the malleus and body of the incus, which is the beginning of the mastoid antrum.

When the perforation is in the anterior part of the membrana flaccida, the Valsalvan inflation is likely to produce a characteristic perforation-whistle, but when the perforation is elsewhere in the flaccid membrane, a perforation-whistle on inflation by any means is not likely to be produced, as can be readily understood upon reflecting, that, except in anterior perforations, the body of the malleus and incus intervene between the cavity of the tympanum and the perforations. Another feature in these cases of perforation in the membrana flaccida, is the absence of perforation in the membrana tympani below the folds. I have only once observed a perforation here coexistent with perforation in the membrana flaccida. Dr. C. J. Blake[1] has given an account of a case in which a small perforation in the flaccid membrane was associated with a large opening in the membrana tympani proper. Sometimes, especially in the posterior forms, denuded bone can be felt through these perforations. My experience in this form of aural disease extends over twelve cases. Perhaps one of the rarest circumstances in these cases is to find a similar perforation, or, in fact, a perforation of any form, in both membranæ flaccidæ existing at the same time. An account of such a rare occurrence will be given in Case VII.

Treatment.—The existence of a perforation in the membrana flaccida, excepting, perhaps, the central variety, indicates great disease in the upper part of the tympanic cavity. As the bulk of the malleus and incus lies in the dome of the tympanum, directly behind the membrana flaccida, there is necessarily an impediment offered by them to the escape of matter from the cavity of the drum, when the only perforation in the membrana tympani is in the flaccid part.

The only efficient treatment of tympanic disease, in these cases in which the perforation in the flaccid membrane is but a symptom of the position of the disease, is by means of the tympanic syringe. The form I have used for some years is that described by Dr. C. J. Blake. It consists briefly in a dentist's syringe of hard rubber, about 9 cm. long, and about 1.50 cm. in diameter. To this is added a short tube of glass, making a transparent "neck," in diameter 5 mm. to which curved nozzles 9 cm. in length, with diameters varying from ½ to 1½ mm. may be fitted. The neck alluded to above may be of

Fig. 85.



Blake's Middle-ear Syringe.

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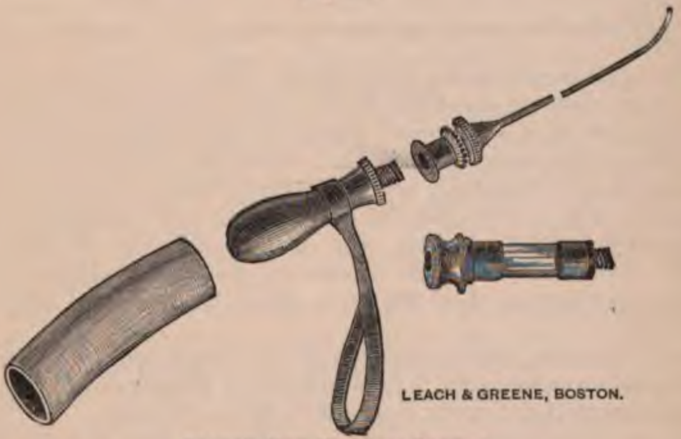
[1] Transactions American Otological Society, vol. i. p. 546, 1875.

glass or metal, and should be made to screw off and on. A metal "neck" has proved most satisfactory to the writer, because much more durable than glass. With such an instrument the surgeon can both cleanse and medicate directly a diseased tympanum far better than in any other way. The experiences of J. Orne Green,[1] C. J. Blake,[2] A. H. Buck,[3] and H. G. Miller,[4] are of great interest and value in further elucidation of this important form of aural disease.

Dr. C. J. Blake[5] writes me the following description of his new tympanic syringe. It is a sort of combination of the middle-ear syringe, and Hartmann's canula, and is useful in washing out the middle ear. It consists of a brass tip with a small handle on it; over one end of this tip is slipped a rubber tube connecting with any form of rubber syringe—Davidson's or a bag-syringe, for instance—and to the other end screws any one of the slender canulæ, such as are used with the middle-ear syringe; it is, *per se*, properly not a syringe, but the middle-ear nozzle for a syringe.

Fig. 86.



Blake's New Tympanic Syringe.

Case I. *Chronic discharge from the tympanum, with perforation of the membrana flaccida posteriorly.*—John M., seventeen years old, came under my care in the Presbyterian Hospital of Philadelphia, in July, 1872. He states that his first ear-trouble occurred when he was four years old. He is a pale, intelligent lad, a hard student in a classical school. His father died insane, and he has a brother who is hopelessly insane. When the patient was twelve years old he began to have "gatherings in his ear" about twice each winter. A year before he became my patient, a constant and most copious discharge, preceded by pain, became established in the right ear. When I made my first examination of his ear, in July, 1872, the membrana tympani was found saturated with a yellowish-green pus. The only perforation in the membrana tympani was in the membrana flaccida, above and behind the short process of the malleus, but at no time was there a perforation-whistle obtained by any mode of inflation of the tympanic cavity. The hearing was reduced to $\frac{6 \text{ in.}}{50 \text{ ft.}}$ for the watch, and for the voice, nil. I passed a probe a short distance into the perforation. The cavity was sensitive, but there was no denuded bone. The treatment consisted of instillations of a solution of nitrate of silver (80 gr. to f℥j) once a week, at the hospital, and the patient was ordered to syringe his ear three times daily at home, and to instil a solution of zinc (gr. x to f℥j). For the latter solution were sometimes substituted solutions of alum, and later a solution of nitrate of lead. In four months the discharge ceased, the nitrate of lead apparently having had the best effect on the aural disease in this case.

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[1] Boston Med. and Surgical Journal, March 26, 1874.

[2] Transactions American Otological Society, 1874, vol. i. p. 546.

[3] Diagnosis and Treatment of Ear Diseases. New York: Wm. Wood & Co., 1880.

[4] Transactions American Otological Society, 1878, vol. ii. p. 257.

[5] March 31, 1884.

In November, five months from the beginning of treatment, the membrana tympani had assumed an almost normal appearance, except the cicatrix in the membrana flaccida.

At no time were there any granulations, and the discharge remained, uniformly, of a light color, and of the consistence of cream. The hearing improved to $\frac{50 \text{ in.}}{50 \text{ ft.}}$ for the watch, and the voice could be heard close to the affected ear. The Eustachian tube was pervious.

On the first of January, 1873, the patient was found complaining of pain and soreness in the mastoid process of the affected ear, but he had no symptoms of fever. Perfect physical rest, with attention to general health, was ordered, and by the 10th of the month all mastoid symptoms had vanished. There was no return of the discharge as the pain subsided, but, as the patient was studying too much at his school, his health began to fail, and he was, therefore, ordered to quit school and take as much exercise in the open air as possible.

By the 1st of December, 1873, the discharge returned, with pain in the ear and soreness when the auricle was pulled gently. The discharge continued for three months and a half, with persistence of the old perforation in the membrana flaccida. I could readily see the discharge oozing slowly from the perforation, after drying the orifice with the cotton-holder.

At this second attack of discharge from the ear, the strength of the solution of nitrate of silver was increased to 480 gr. to f℥j. This caused intense pain for a few minutes; then the pain ceased entirely. In conjunction with applications of the strong solution of silver, the patient used a strong solution of the sulphate of zinc (30 gr. to f℥j) at home, which seemed to exert a good effect in the course of one month. The most careful syringing became necessary while using this strong solution of sulphate of zinc, in order to remove the coagula produced by it. A few painful furunculi followed the cessation of the discharge.

On the 22d March, 1874, the voice and the watch were heard five paces. There was a depressed cicatrix in the membrana flaccida, above and behind the short process. The membrana tympani, below the folds, was almost normal in color.

This case came on with attacks of great pain, while the patient was a child; there was no denuded bone; the perforation in the membrane was just large enough to admit the small round head of a silver probe, and there were from time to time attacks of pain and throbbing in the affected ear, and finally the discharge ceased under the use of astringents, in stronger solutions after the relapse, than at first; there was marked hardness of hearing, but no tinnitus at any time.

It is of interest to note that the first cure was effected in the autumn of 1872, with no relapse until the winter of 1873–74. In the winter of 1872–73, there were simply ten days of mastoid soreness and pain, with no discharge. The patient has resumed his studies at school, and has gained in stature, strength, and hearing.

Throughout the previous history of this case there is shown a tendency to recur; but during the two years he was under treatment, he had only eight months of aural discharge, viz., the first four months, which were followed by one year of freedom from aural discharge, and then a recurrence of otorrhœa for three and a half months, which brings the history to March, 1874, after which date the patient went to reside in another city.

The patient remained away, and did not give any report of himself until November 26, 1875, when it was found that the discharge had returned, and that a small polypus was protruding from the perforation in the membrana flaccida. The polypus was easily removed, but its precise point of attachment could not be determined. A small piece of cotton on the holder was moistened with chloroacetic acid and passed through the perforation, and thus near to the attachment of the polypus. The patient then passed from observation on account of his residence in a distant city.

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[1] I have ceased to use this acid in the ear, on account of the pain it induces.

On the 2d of February, 1879, I found the external auditory canal tumid at the inner and upper end, where it joins the membrana tympani, and the latter in its posterior half seemed to bulge far forwards toward the anterior wall of the canal. It was pinkish, greatly macerated with pus, looked like ordinary skin, and the malleus was invisible. When the drum-head was pressed upon below, pus welled out from the perforation in the flaccid membrane. The condition of the ear at that time had been brought about apparently by unavoidable exposure to a storm of wind and sleet a short time previous. After the exposure, dull earache was soon felt, then a discharge set in for the first time for nearly four years, and the patient once more sought treatment. The mastoid process was not markedly involved at this time, though it had been some years previous the seat of great pain and tenderness. Denuded bone now could be felt by passing a probe directly through the perforation in the membrane, being in all probability a bare spot on the margo tympanicus, or on the incus. The hearing was greatly reduced, the pain had been very slight within the twenty-four hours just passed, the general health was good, but the right pupil was more dilated than the left. The ear was kept carefully cleansed by warm water syringing for a week, during which the patient was not seen, as he resided in another city, where he was in college.

In the course of ten days, when the patient was seen again, the drum-head had assumed a more normal position and appearance and the malleus was visible. The tympanic cavity was at this time cleansed by the tympanic syringe already described.

After the cleansing, a few drops of a solution of nitrate of silver (80 gr. to f℥j) were injected with the tympanic syringe, through the perforation into the cavity beyond. At home he was to keep the ear clean by syringing with castile soap and warm water. In four days the membrana tympani was seen to have assumed still further a more normal appearance and the discharge from the perforation was less. The same treatment with the tympanic syringe was gone through with and the patient was not seen for a week. When he came again there was scarcely any discharge, and the membrana tympani looked nearly normal below the folds. At this visit, a solution of only sixty grains of nitrate of silver to the fluidounce of water was applied to the tympanic cavity. By the use of the tympanic syringe some cheesy matter was washed out through the perforation in the flaccid membrane, and the patient told to let his ear alone and not to syringe it; but he did not carry out these orders, and when he came again a small polypus was seen to have sprung up over the perforation, very probably as the result of too much syringing. The polypus, which was quite vascular, was pulled away with Blake's snare, and a few drops of a solution of nitrate of silver (480 gr. to f℥j) injected into the cavity through the perforation, without any discomfort or inflammatory reaction. In a week, when the patient was seen again, there was no discharge from the ear. In the course of a fortnight the patient took cold, and there was a slight return of discharge from the ear, accompanied by tumidity and soreness in the region of the perforation and the posterior wall of the inner end of the auditory canal. All these symptoms, however, soon vanished under gentle syringing and the injection of an acid solution of acetate of lead and laudanum, by means of the tympanic syringe.

The denuded surface of bone felt through the perforation, now seemed much less in extent, and gradually it appeared to be covered over with periosteum, as it no longer could be detected with a probe. The hearing became relatively normal, the patient being able to hear the voice three or four feet, and a pocket watch $\frac{6 \text{ in.}}{60 \text{ in.}}$ This improved condition continued for some months, after which, the patient was obliged by various duties to stay in another city.

At no time in this case was there any perforation-whistle upon inflation of the tympanum; there was evidently purulent matter in the cavity of the tympanum, as shown by the welling out of pus through the perforation in the flaccid membrane, when the membrana tympani below the folds was pressed upon.

The hardness of hearing was at times profound, and the symptoms of disease in the back part of the upper tympanum and mastoid region were marked. The unequal dilatation of the pupils is well worthy of note, for it was said by the patient that this had been the case always since his ear had been affected, *i. e.*, since he was twelve years old; it consisted in a partial paresis of the right iris, which, though dilatable, was sluggish under the same stimulus, in comparison with the left, and it would never open as widely as its fellow.

In the treatment it is worthy of note that the tympanic syringe was the only means of cleansing and medicating the diseased cavity, and also that the very strong solutions of nitrate of silver were efficient in their action and caused no pain.

CASE II. *Perforation of the membrana flaccida.*—A second case of perforation of the membrana flaccida (Shrapnell's membrane) was observed in a man 22 years old. He stated that the first symptom in the affected ear, the left, was an attack of pain which had occurred seven months previous; this was followed by a discharge, which had gradually become less. Becoming anxious to have it entirely checked, he had applied for treatment.

The perforation was large, embracing most of the flaccid membrane and exposing the neck of the hammer. The discharge was very slight. Unfortunately for the further history of this case, like many others seen in public practice, it passed from notice after the second visit. The hearing in this case was greatly impaired. There was no perforation-whistle produced in this case at any time by any mode of tympanic inflation.

CASE III. *Perforation of the membrana flaccida; polypus protruding through the opening thus made.*—A fourth case presents more clinical interest, as it had been long watched, from Sept. 7, 1875, to Sept. 1877. The patient, a German woman, 35 years old, stated that two years previously her left ear had troubled her for the first time. There was then some pain followed by an offensive discharge; the latter had continued, greatly to her annoyance. The hearing was reduced to $\frac{3 \text{ ft.}}{60 \text{ ft.}}$ for the loudly ticking watch; for the voice, similarly. The meatus was found smeared with a slight but offensive discharge which came from a large perforation in the flaccid part of the membrana tympani. The membrane was not perforated elsewhere, but it appeared abnormally thickened, as it always does, so far as my experience goes, when a perforation exists in the membrane of Shrapnell. A polypus as large as a small pea protruded through the perforation. The attachment of the polypus was inside the tympanum, posteriorly; when it had been removed, which was easily done with a hook, it was found that the polypus attached posteriorly had grown forward between the membrana tympani, *i. e.*, the region of the perforation, and the contents of the upper part of the tympanic cavity. Its inner surface was flattened; its outer surface, being free to grow out through the perforation, had assumed a convex shape, and this it was which was seen protruding through the opening in the membrane.

There was no perforation-whistle at any time. The ear was kept carefully cleansed, and chloroacetic acid[1] was applied by means of the cotton-holder to the perforation and the tympanic cavity adjacent to it. The patient syringed the ear two or three times daily at home, and instilled a weak solution of zinc. The discharge diminished greatly, lost its fetor, and at last ceased entirely. The hearing was not materially improved, as indeed might be expected, when it is remembered how near the articulations of the ossicles the brunt of the disease must have fallen. Indeed, I have yet to see a perforation of the membrana flaccida unattended with great deafness.

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[1] I have long since ceased to use this acid, on account of the great pain it induces.

CASE IV. *Perforation of the membrana flaccida, probably from external causes; foreign body in the canal.*—This case, besides presenting the comparatively rare occurrence, perforation of the membrana flaccida, also furnishes an example of the still rarer feature of being probably caused by external erosion. The patient, a Scotchman, 35 years old, complained of an intense pounding noise in the right ear, which caused him much annoyance, and brought on frequent attacks of headache and dizziness. In the diseased ear the watch was heard only in contact with the auricle. His aural discomfort, which had become especially annoying to him within several years, had led him to pick at his right ear, from which he had now and then brought "small pieces of something which had an offensive odor." He was entirely unsuspicious of the presence of a foreign body in the ear.

The examination of the ear revealed an apparently free auditory canal, but a very much thickened and irritated yet imperforate membrana tympani. From the line of the folds of the latter and the short process, over the region of the membrana flaccida and the inner portion of the upper wall of the auditory canal, *i. e.*, the segment of Rivinus, there seemed to be dark adherent wax. Upon laying hold of this obstruction, it was easily removed, and proved to be a grain of corn imbedded in cerumen. The place occupied by this mass was very much altered in appearance. From the line of the folds of the membrane to the segment of Rivinus, *i. e.*. the region of the membrana flaccida, appeared much more extensive and sunken than usual; from the segment of Rivinus outward along the upper wall for one-eighth of an inch, the bony roof of the auditory canal seemed greatly hollowed out, into a dome-like space, and here the greater portion of the grain of corn was lodged.

The membrana flaccida appeared to be destroyed; at the place usually occupied by it there was a whitish, roughened, cicatrized depression, bounded below by the distinct upper edge of the membrana tympani proper.

Upon inflation the membrana tympani below the folds bulged, but no air escaped from the region of the flaccid portion. The membrana flaccida had been eroded apparently by external pressure in this case.

The foreign body had been in this man's ear probably twenty-five years, as gleaned from the apparently trustworthy history of his life.

Upon the removal of the foreign substance from the ear in this case, the subjective noise and the disagreeable head-symptoms ceased, but the hearing was not improved, which would seem to show that the impairment of this function was due to a process of disease in the tympanum, probably in its upper part, in the region of the membrana flaccida, and not dependent upon the presence of the foreign substance.

CASE V. *Ulceration of the membrana flaccida, from external irritation.*—This case, without presenting a membrana flaccida entirely perforated, was unmistakably one of ulceration of this part of the membrana tympani, due to pressure of a plug of hardened cerumen. The patient, a man forty years old, complained of dull aching in the ear of several days' duration; the hearing was only slightly diminished. Upon inspection the canal was found to be filled with cerumen, and the membrane consequently hidden from view. After removal of the obstructive mass, the only change observed in the drum-head was an ulcerated spot in the membrana flaccida, immediately above the short process of the malleus. This ulcer was about 1.50 mm. in diameter, and bled slightly on being touched; it was tender on gentle pressure. The ear was let entirely alone for a week, at the end of which time the ulcer had healed, and the ear had resumed its entirely normal function. This case furnishes another example of the fact that the membrane of Shrapnell may be ulcerated from without.

CASE VI. *Perforation in the anterior part of the membrana flaccida, right ear; polypus attached to the perforation and occupying the entire membrana flaccida.*—On August 14, 1878, Frank C., aged twenty seven, a merchant, presented himself for treatment for a disagreeable aural discharge and deafness in the right ear. His statement was that three years previous he had suffered, for the first time, from earache and a running from this ear, since which time more or less discharge from the right ear had continued.

An examination of the case revealed almost total deafness on the right side, the voice being heard only when close to the ear; the other ear was normal. The tuning-fork on the vertex was heard best in the diseased ear. There was no pharyngeal disease. Inspection of the membrana tympani revealed a normal drum-membrane, bathed slightly by pus, which seemed to flow over it from a bright polypus seated over the entire membrana flaccida. The folds of the membrana tympani were well marked, and above them the polypus lay. The polypus was extracted by means of a snare, with a narrow canula, as modified by myself, for conveying the wire, and the attachment, which seemed broad, was touched with a saturated solution of nitrate of silver (480 gr. to f℥j), conveyed to it by means of a small roll of cotton on a cotton-holder. The attachment was treated the same way on the third day after, and when seen two days later the pedicle was no longer visible, thus leaving a free surface over the entire membrana flaccida, which appeared more hollowed than usual, and the folds of the membrana tympani were thus thrown into greater prominence.

More or less discharge, however, continued to come into the auditory canal from a perforation in the anterior part of the membrana flaccida, which perforation had been discovered after the removal of the polypus, which seemed to spring from its neighborhood. This discharge seemed to be diminished by the use of alum in and about the perforation, and finally, in less than a month and after a few applications, it ceased entirely for nearly a fortnight.

On the 24th of September, a little over a month from the time the patient was first seen, a slight hemorrhage occurred from a small vessel running in the membrana flaccida, and a slight discharge set in from the tympanic cavity through the opening in the membrana flaccida. This was controlled by the use of powdered alum, and the ear became dry, no granulations were visible, and the swelling about the perforation went down. The neck of the malleus could now be seen, and pressed upon and moved by a probe through the perforation in the membrana flaccida, showing that the opening had extended from the front to the central part of the flaccid membrane. The probe could be passed four mm. point-blank into a cavity, beyond the perforation. The discharge, however, returned again in slight quantity, and a new treatment was used in the form of the tympanic syringe. By this means in less than a month the case was permanently cured of the discharge, and the hearing was restored, as the rest of the notes will show.

The first injections were made on October 1st. A nozzle, which is slightly curved, was used and turned toward the tegmen tympani. By this means a mixture of warm water and alcohol was first used, whereupon a little earache ensued, for a few minutes. The next day a little tenderness was complained of, and the pus seemed a little more copious, but laudable. The tympanic cavity was then cleansed with warm water by means of the tympanic syringe, and afterward a few drops of a solution of nitrate of silver (gr. v to f℥j) were injected by the same means. On the next day the discharge seemed greater, and the patient complained of a feeling of soreness deep in his ear. I desisted, therefore, from the use of the tympanic syringe; but the true cause of the increased discharge and pain seemed to be a cold which was fully developed by the next day. The discharge seemed now to diminish, but it persisted, and in the course of two days the cleansing and medication by means of the tympanic syringe were resumed, and after some cheesy matter had been washed through the perforation, a few drops of a stronger solution of nitrate of silver (gr. lx to f℥j) were injected into the cavity. No discomfort of any kind ensued, but the patient expressed himself as feeling "comfortable in the ear," and in the course of three days, when he called again, a throbbing, which he had often felt in his ear had ceased. At this visit the tympanic syringe was used only for cleansing the cavity, and a little cheesy matter was washed out.

On the next day, October 9th, a mere trace of creamy pus was seen around the perforation, the membrana tympani below the folds was dry and lustrous, the entire ear felt comfortable to the patient, and the hearing began to improve. At this time the cavity was cleansed with the tympanic syringe and a very little inspissated matter was washed out, after which, by the same syringe, a few drops of a stronger solution of nitrate of silver (gr. lxxx to f℥j) were similarly injected. No pain or discomfort of any kind ensued. In the course of two days when the patient was next seen, a little discharge was found coming from the perforation, though the patient was not conscious of any moisture in his ear. Nothing had been done to the ear by the patient in the interim of the visits at any time, as all the local treatment was applied entirely by the writer. The discharge seemed at this visit a little stained with the silver solution, but its entire amount was not more than a small drop. The cavity was syringed out by the tympanic syringe, and a few whitish flakes were thus removed; after which a few drops of a still stronger solution of nitrate of silver (gr. c to f℥j) were injected into the cavity with the tympanic syringe. No pain nor discomfort ensued, and the space beyond the perforation was dried out by means of absorbent cotton on the cotton-holder, after the auditory canal had been syringed, so as to leave no solution of silver there. On the next day there was *no discharge* visible, the perforation was *dry*, and the cotton on the cotton-holder, passed into the cavity through the perforation, brought out a little brownish matter. The cavity was then syringed with warm water by means of the tympanic syringe, but no flakes were thus removed, and no application of silver was made.

In two days, during which nothing had been done to the ear, it was found to contain no discharge, and the membrana tympani was dry in all parts. The cavity was simply wiped by absorbent cotton, but no medication was applied to the ear. The next day the ear was found to be still entirely free from discharge, and the patient could hear with this ear a whisper at ten feet. A few brownish silver-stained flakes were at this visit washed from the cavity by means of the tympanic syringe. The patient was not seen again for a week, when it was found that the ear was entirely free from discharge, and again in a week later when he was seen, the ear was found to be entirely free from discharge, and the perforation was closed by a thin, brownish pellicle, varnished in appearance, and probably a fresh growth of delicate cutis from the upper wall of the external auditory canal.

It seems fair to conclude that this case was speedily cured by the use of the tympanic syringe.

CASE VII. *Anterior perforation in each membrana flaccida; naso-pharyngeal catarrh; purulent discharge from each tympanic cavity.*—Theodore M., aged 10 years, is said to have had discharge from his right ear when two years old, the only cause of which is said to have been cold in the head. Some years later the left ear began to discharge from apparently the same cause, and both have run greatly ever since. Four years ago he had measles, since which the ears have been worse.

The case came under my observation through the courtesy of Dr. H. N. Spencer, of St. Louis, Mo. Upon inspection I found each external auditory canal half filled with offensive purulent matter, and a perforation, anterior to the neck of the malleus in each membrana flaccida; the rest of each membrana tympani was intact. The nares were chronically inflamed, and the naso-pharynx clogged with a scanty, tenacious, yellowish mucus, all of which induced the child to breathe through his mouth. The alæ of the nose were hence weak, ill-developed, and the nose looked pinched and too small for his face. There was not, nor has there ever been, any bleeding from the nose, nor can blood be obtained on cotton on a probe, passed behind the velum into the naso-pharynx, as there would be were granulations there. His lips were usually parted and dry, and the fauces looked as those do which are exposed to respiration through the mouth.

The hearing on the left side was for the voice two and one-half feet, and on the right side, four feet. Both ears were easily inflated either by Politzer's method or by Valsalva's, the perforation-whistle being very loud, and pus was seen to issue from the perforations during the latter inflation. The general appearance of the patient was strumous.

Treatment.—Each day the ears were syringed, first with an ordinary syringe, and then each tympanic cavity was cleansed, through the perforation, by means of the tympanic syringe. After the ears were thus cleansed, there was syringed into each tympanic cavity a small quantity of absolute (anhydrous) alcohol. The naso-pharynx was touched each day, by passing behind the velum a tuft of cotton on an aluminium probe, soaked with the following mixture:

℞—Potassii iodidi, 0.50 ctgr.
Tr. iodinii, 5 ctgr.
Aq. destill., 10 ctgr.

This treatment was carefully carried out every week-day for a month, during which the nasal respiration improved, and there was much less hawking, especially in the mornings, on getting up.

The aural symptoms did not improve under the alcohol treatment, the matter discharged was markedly purulent, and it might be said that the ears were exactly as they were before the month's local treatment. Sometimes the left ear seemed to discharge less, but I learned that this had always shown periods of less discharge under other forms of treatment.

Therefore, on November 8, 1880, after one month of observation of the case and the above treatment of the ears, the treatment was changed from the alcohol applications to the use of strong solutions of nitrate of silver. On that date, the tympana were cleansed as formerly with the tympanic syringe, and then a few drops of a solution of nitrate of silver, sixty grains to the fluidounce of water, were injected through the perforations into each tympanum by the tympanic syringe. This caused no sensation of any kind to the patient, and on the next day, after cleansing as usual, a few drops of an eighty-grain solution of nitrate of silver were injected into the tympanum with the tympanic syringe. On the following day, *i. e.*, after two applications of nitrate of silver as above stated, the discharge seemed slightly less, and the tympana were cleansed simply, without receiving any treatment with a solution of nitrate of silver. The eighty-grain solution of silver was applied again on the 11th of November, but nothing except cleansing was done to the ears on the 12th, when the discharge seemed lessening. The fauces were still touched every other day with the iodine solution above described.

The alæ of the nose seemed stronger when felt during his movement of them, between my thumb and forefinger; his respiration became less by the mouth, and he hawked and spat less from his throat and blew less from his nose.

The case just narrated teaches very little, if anything, by its treatment, except perhaps the stubbornness of such forms of disease. The Valsalvan inflation caused pus to flow from the perforations and gave a loud perforation-whistle, which is interesting, as usually perforations in the membrana flaccida are not attended with a perforation-whistle on inflation. A perforation, too, in each membrane is noteworthy, as well as the youth of the patient, these perforations, as a rule, not being observed in so young a subject. The case is given, therefore, on account of its history and description, rather than for the success of its treatment, which, by November 15, 1880, had not controlled the disease to any marked degree.

CASE VIII. *Destruction of the entire left membrana flaccida; erosion of the margo tympanicus; exposure of the head and neck of the malleus and of the body and proximal part of each crus of the* *incus.*—Miss H., aged thirty-five years, came under observation November 3, 1880, and stated that she was affected by pain and discharge in the left ear, in early childhood. The previous summer, in August, she bathed freely in the surf at Cape May, and expôsed herself to the full entrance of water into both ears. She finally, after two or three weeks of such exposure to cold salt-water, observed tinnitus and hardness of hearing, with some pain in the left ear. At this time some hardened secretion was washed from her ear, which relieved the tinnitus and hardness of hearing, the pain having already ceased. Dr H. S. Schell, who attended to the case for me, ordered her at that time to use a warm-water aural douche, but she could not employ it on account of the great dizziness caused by it. The membrana tympani was found to be red, opaque, and flat, and the watch was not heard in this ear, but the tuning-fork, on the vertex, was heard best in this ear. Air entered the tympanum upon inflation, but no perforation-whistle was elicited.

In the course of a day or two, the destruction of the flaccid membrane was diagnosticated, and from the cavity beyond, a cheesy mass was removed, and the hearing rose to six inches for the watch.

On November 3, 1880, when first observed by me, entire destruction of the flaccid membrane was seen, with extensive erosion of the margo tympanicus, which exposed to view most distinctly the head and neck of the malleus and the body of the incus, with the proximal parts of each crus. These ossicles, so far as could be seen, were covered with their natural mucous-periosteal covering, and were white and shining. Entirely around and above them there was a semicircular opening, four mm. in diameter, which permitted a view into the upper part of the tympanic cavity, under the tegmen. This cavity was partially packed with cheesy débris, after removal of which the mucous membrane lining the cavity could be seen by careful illumination. This membrane was not very red, but looked puckered, and excreted a thick, offensive, dark, and scanty matter, not sufficient, however, to bathe the membrana tympani below the folds. When first seen by me, there was also a slight hemorrhage, which continued for two days to trickle from the back part of the cavity over the back part of the drum-head and out at the meatus. This had been observed at the meatus by the patient for a day previous to her coming to me. Her hearing at this time in the affected ear was three to four feet for words spoken in a low tone.

Cleansing the tympanic cavity by means of the tympanic syringe could not be carried out, because of the great dizziness brought on by a trial of it. Recourse was then had to absorbent cotton on the cotton-holder, by which the cavity was very gently swabbed out. After the offensive matter had been removed in this way, the cavity was further swabbed out by absorbent cotton, soaked in Condy's fluid (permanganate of potash) and warm water. After thus cleansing and disinfecting the cavity it was medicated by conveying to it, in the same manner, some of the following mixture:

℞.—Liq. plumbi subacetatis,	♏xx.
Acidi acetici diluti,	♏vi.
Liq. opii sedativi,	♏xx.
Aquæ,	q. s. ut ft. f℥j.—M.

Under this latter method of daily cleansing and medicating by cotton on the cotton-holder, the discharge ceased in twenty days, and all signs of otitis externa diffusa which had existed, during the first part of the observation of the case, disappeared. There had been pain at times, referred to the left eye and brow, and under the left ear; sometimes a pain had darted from the left ear backward toward the occiput. The perforation became much smaller and seemed likely to close entirely.

Case IX. *Chronic purulent otitis media on both sides; entire destruction of the flaccid membrane on the right side.*—On December 4, 1877, the Rev. Mr. Y., forty years old, consulted me about a discharge from both his ears, which had existed since scarlatina in early childhood. He was of German origin, and had endured a life of hardship as a boy, when he had been beaten a good deal about his head. The hearing in his left ear was nearly gone, but the right ear, notwithstanding the destruction of the flaccid membrane, retained its function almost entirely.

The destruction of the membrana flaccida had been accompanied by a destruction of the head and neck of the malleus and the body of the incus; the manubrium of the malleus, however, remained attached to the membrana tympani. All the membrana tympani proper behind a line marked by a prolongation of the long axis of the manubrium was also destroyed, and the red, velvety mucous membrane of the tympanic cavity could be seen beyond the remnant. The condition of the stapes could not be made out.

The good hearing in this case, in spite of the great and peculiar destruction in the sound-conducting parts, must, I think, be accounted for by the free access the sound-waves had to the tympanic cavity, and both fenestræ.

Case X. *Chronic purulent discharge from the right ear, with polypus attached to the perforation in the back part of the membrana flaccida.*—Miss D., aged twenty-five years, came under observation January 25, 1880. A slight purulent discharge was coming from the right ear. Upon inspection, a polypus was found attached to the posterior part of the membrana flaccida; the polypus being removed by Blake's snare, a perforation in this membrane was detected. The point of attachment was touched with chromic acid, in five days a little powdered crude alum was blown into the fundus of the ear, over the perforation, and with one or two repetitions of this, in less than a month the discharge ceased, and the perforation in the flaccid membrane closed. An interesting feature in this case was that in *the left ear* there was a cicatrized perforation in the central part of the flaccid membrane.

The hearing in the right ear had not been affected by the disease, to any extent, which leads to the idea that the disease of the flaccid membrane in this case had arisen from without, and by erosion, as the patient had been in the habit of picking her auditory canal with pins and the like.

Of the ten cases of perforation of the membrana flaccida, here presented, the following synopsis is given:

Sex	Males, 7. Females, 3.
Ear	Right, 5. Left, 3. Unrecorded, 1. Both sides, 1.
Position	Anterior 2 (in the double case, Case VII., the perforations were anterior). Posterior, 3 Central, 3 Entire destruction, 2.
Cause	External (traumatic), 3. Internal (tympanic), 7.

In four instances in which there was marked tympanic disease with discharge, a polypus was found growing from the perforation. In the treatment of the tympanic disease, which is usually the cause of the perforation in the membrana flaccida, no means of cleansing and medication is so efficient as the tympanic syringe.

The author has under observation, at the present time, two cases of perforation of the flaccid membrane: one anterior, in a man, 32 years old; the other, an anterior perforation, in a woman, 30 years old. Both have been attended with severe pain and discharge, at times, before coming under treatment. The cause in each seems to have been tympanic inflammation. Both have yielded greatly to treatment by antiseptic powders and solutions.

INJURIES OF THE MEMBRANA TYMPANI.

The membrana tympani is liable to a number of injuries from without. These, while not directly interfering greatly with the function of hearing, unless at the same time they affect deeper parts of the organ of hearing, usually expose the mucous lining of the tympanic cavity to the direct irritation of the external air, by perforating the membrane, and thus lead secondarily to inflammation and loss of hearing.

Prominent among the causes which lead to traumatic rupture of the drum-head may be cited, boxing the ears, and receiving the force of a wave on the ear while bathing in the sea. The healthy membrane will usually resist these forces, but of course one which is any way diseased by fatty degeneration, atrophy, and by calcareous deposits, or one prevented from assuming proper equilibrium, by a closure of the Eustachian tube, is extremely liable to yield to external violence above named.

The drum-head may receive very injurious concussion from diving into the water, from the discharge of musketry or of a cannon, from falls, or from a gunshot wound near the ear, as, for example, in the upper maxilla and the horizontal plate of the ethmoid,[1] and also from the kick of an animal on the mastoid process. The membrane is also often injured by the sudden introduction of long and slender instruments or implements into the auditory canal.

In the case of a young man, 21 years old, killed by a fall from his horse, upon a pavement, the left membrana tympani was found to have been fissured in the posterior half. The length of the fissure was 2½ mm.[2]

In some cases of traumatic rupture of the drum-head, the primary wound is followed by symptoms of aural vertigo, as has also been noted by others.[3] The following case shows such vertiginous symptoms:

John M., Englishman, married, 30 years old; the patient looked thin and somewhat anxious when he presented himself for treatment. The history given was that, the evening before, while sitting quietly reading, a companion playfully boxed him on the ear. Instantly he felt a roaring in the ear, but fortunately did nothing in the way of pouring in fluids with the view of relieving the noise and hardness of hearing. The following morning it was found, on inspecting the membrana tympani, that it was ruptured in the posterior and lower part; that the diameter of the perforation was about 2 mm., and that there was little or no congestion in the drum-head. The patient had suffered greatly from heat of the previous night (it was July), and had been exhausted by nursing a sick infant. Upon his rising suddenly in my office, he grew very pale, said he was dizzy, and fainted. It was a long time, an hour or more, before he could go home, and then only in charge of an attendant. He remained very dizzy all day, but, the perforation healing in the course of a few days, the hearing became good, but not entirely normal, and the symptoms of dizziness disappeared.

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[1] Casuistische Beiträge zu den traumatischen Verletzungen des Trommelfells. Dr. E. Zaufal Archiv f. Ohrenheilkunde, Bd. i., N. F., S. 188, 280, and Bd. ii. S. 31.

[2] Trommelfellbefund nach Sturz mit dem Pferde. Dr. Trautmann. A. f. O., Bd. ii., N. F., S. 101.

[3] Fall von traumatischer Ruptur des Trommelfells mit Symptomen von Labyrinthreizung. Dr Parreidt. A. f. O., Band ix. S. 179. Dr. Holmes; Trans. American International Otological Congress, 1876.

Probably the perforation, by taking away some of the power the drum-head has of resisting the traction of the tensor tympani, had allowed the latter to draw the chain of ossicles inward, producing temporary pressure in the labyrinth, with consequent dizziness.

The membrana tympani has been found ruptured in those who have been executed by hanging. Dr. Ogston[1] has described such a case in which the fissure of the drum-head was ragged, and running from the tip of the manubrium downward towards the periphery of the membrane. The edges were everted, but there was neither blood nor any other fluid in the cavity of the drum. From the eversion of the edges in such a case, it might be supposed that the force which breaks the membrane acts from within the tympanic cavity, outward. The rupture of the membrane in such cases may be explained by supposing that the air in the tympanum, at the moment of the fall, is thrown into violent concussion, and, not being able to escape by the Eustachian tube, owing to the constriction of that canal by the rope, it is forced violently outward, producing the fissure of the membrana tympani. The membrana tympani may be ruptured by an increase in the external atmospheric pressure, if the latter is very extraordinary, and if the Eustachian tube is more or less impervious.[2]

The membrana tympani is probably able to endure sudden pressure from without, as in discharges of artillery, musketry, etc., whether expected or not, only through the loose valve-like nature of the Eustachian tube. This seems fully shown by the observations and experiments of Rüdinger, Brunner, Lucæ, and the observations of John Green, referred to.

Fracture of the Handle of the Malleus.—There are a few cases of fracture of the handle of the malleus on record. This rare accident has been described by Ménière,[3] von Troeltsch,[4] and R. F. Weir;[5] the first observed it in the ear of a gardener, who had thrust his ear against a twig, while working; and the second saw a fracture of this part of the malleus, resulting from the accidental thrusting of a penholder into the auditory canal. In both cases the manubrium appeared to have united. Dr.

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[1] Archiv f. Ohrenheilkunde, Band vi.

[2] Dr. John Green, "Condensed Air, 60 lbs. to square inch; its Effects on the Eustachian Tube." Tr. Amer. Otol. Soc., vol. i p. 129, 1870.

[3] Gazette Méd. de Paris, p. 50, 1856.

[4] Treatise on the Ear, p. 151.

[5] Ununited Fracture of Manubrium of Malleus, Tr. Amer. Otol. Soc., vol. i. p. 121, 1870.

Weir's case presents the additional rarity of an ununited fracture of the manubrium. It occurred in an Irish laborer, in consequence of a fall from a height of fifteen feet, four months before Dr. Weir saw the case. The lower portion of the manubrium was seen to be distinctly movable upon the upper part, whenever the tympanum was inflated. The fracture occurred just below the short process; inflation restored the parts to their normal position, but displacement occurred again in about fifteen minutes. Dr. C. S. Turnbull[1] observed a fracture in the manubrium mallei, near its lower part. Union finally occurred and was marked by distinct hyperostosis. I recently saw, in the Philadelphia Polyclinic, a malleus from which the lower two-thirds had been broken off, by endeavors made to remove with instruments a foreign body, many years before. The membrane had grown around the short stump of the manubrium.

Atrophy of the drum-head may occur in consequence ot pressure, long kept up, by a mass of hardened cerumen. This process is favored if the Eustachian tube is at the same time closed.[2] It is not uncommon to find, in those suffering with chronic aural catarrh and deafness, hardened pieces of ear-wax in contact with the drum-head. Though such an obstruction may add nothing to the existing deafness, it may and often does produce sensations of fulness in the head, and, at times, vertigo. Such cases are apt to escape detection, simply because the patients have given up all treatment, considering their cases hopeless, and are no longer under examination. Although the deafness may remain unchanged after the removal of such masses of cerumen, the cerebral symptoms are greatly relieved.

Reproduction of the Membrana Tympani.—The popular impression, that the membrana tympani once perforated can never be healed, is a wrong one. The drum-head, on the contrary, has great power of healing and restoration, as shown by Dr. H. N. Spencer[3] and others. A simple slit in it will heal in a few hours if there is no inflammation in the drum-cavity. Larger, and even gaping, perforations, caused by disease, tend to heal, unless the disease in the tympanum keeps up and leads to a cicatrization of the edges of the opening in the membrana tympani. The tympanic disease behind the perforated drum-head should receive more attention than the simple perforation, which is but the vent for the hypersecretion resulting from the disease in the middle ear. It is, therefore, not only unwise, but harmful, to attempt to close, by stimulation of its edges, a hole in the membrana tympani. If one should succeed in doing it, so long as the mucous membrane behind it is diseased, the closing of the perforation would deprive the drum-cavity of a direct way of treatment of its diseased lining, and sooner or later the drum-head would give way again. It is not easy however, to cause a perforation in the head of the drum to heal while disease exists behind or about it. In endeavoring to do this, by stimulation of its edges, the hole is most usually made larger.

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[1] Phila. Med. and Surg. Reporter, Feb. 22, 1879.

[2] S. Moos, Archives of Oph. and Otol., vol. i. pp. 321, 324, 1869.

[3] Case of Reproduction of the Membrana Tympani, Transactions American Otol. Soc., vol. i. p. 179, 1871.

In the *Philadelphia Medical Times* for May 10, 1873, No. 80, vol. iii., I reported a case of restitution of the membrana tympani after fifteen years of disease. The chief features of the case were as follows: On the last day of July, 1872, Christian L., a German, 15 years old, consulted me respecting a chronic discharge from his right ear. The disease dated from infancy, without any history of a discharge from the left ear. All the statements of the boy were corroborated by his father, who accompanied him. Examination revealed the presence of a copious, light-green discharge in the meatus. Upon removal of the obstruction in the canal, a large perforation was discovered in the upper posterior quadrant of the membrana tympani. Hearing distance for watch $\frac{15\text{ ft.}}{60\text{ ft.}}$. Eustachian tubes pervious to inflation by Politzer's method. After cleansing the auditory canal and middle ear as thoroughly as possible, I instilled ten drops of a strong solution of nitrate of silver (ʒj–f℥j) into the ear. This was syringed out in a few moments, and the lad ordered to syringe his ear at home thrice daily, with warm water, and after each syringing to drop into the ear ten drops of a two-grain solution of sulphate of zinc warmed, and to allow the latter to remain in the ear five minutes. One week later I saw the boy; his ear was much better, and he was ordered to continue the treatment. By the middle of August, two weeks after he was first prescribed for, the discharge from the ear had ceased, and the hearing for the watch had increased to one-half the normal distance. A few days later, the perforation in the membrana tympani had closed, and the membrane, which at the time of the first examination was swollen and discolored, had assumed the normal lustre. The hearing had now become normal, and the drum-head was entirely restored. Sometimes the membrana is restored after entire destruction of the malleus, a thin membrane, chiefly dermoid, taking the place of the normal membrane. Even with no discernible malleus or parts of it, nor of the other ossicula, the hearing may be good. Usually, however, it is much impaired in those cases of reproduction of the membrane in which the ossicles are destroyed.

Medico-legal Significance of Injuries to the Membrana Tympani.—After a blow has been received on the ear, either during a quarrel or in play, an action at law may be instituted to recover damages for supposed injury to the drum. The surgeon will be called on, in such cases, to decide, first, whether there has been an injury done the drum-head, and, if so, how far it will impair the hearing. In the first consideration he must bear in mind that the drum-head may have been perforated before the blow was received, though the patient or complainant may or may not know it. The chronic perforation can be readily distinguished from the acute. If it should be determined, however, that a previously normal drum-head has been ruptured by a blow on, or a thrust in the ear, it then remains for the surgeon to determine whether the hearing has been or will be impaired by the injury. The mere fissuring of a normal membrana tympani in the above way may not necessarily injure the hearing, nor oblige the patient to give up his daily work. If, however, there has been a severe blow on the ear, the hearing may be impaired from concussion of the nerve in the labyrinth, which, though associated with rupture of the drum-head, is not necessarily caused by it. If there has been no concussion of the inner ear and no inflammation set up in the drum-cavity, the ruptured drum-head will heal quickly if let alone, *i. e.*, if nothing is dropped or poured into the ear. Ignorance on the latter score has led very often to the use of drops, the moment a fissure in the drum has been noticed. The matters thus poured into the canal, having entered the drum-cavity through the perforation, have set up inflammation in the delicate mucous membrane of the middle ear, and disease has been established where otherwise, by letting the ear intelligently alone, the perforation would have healed in a day or two. Thus it might appear that the blow had caused disease in reality produced by improper treatment of the ear. If, in a case of asserted traumatic violence to the drum-head, deafness should be immediately discovered by the surgeon, it must be determined whether it has been produced by the same blow which has ruptured the drum, or whether it existed before. A temporary diminution of hearing is very likely to occur after a blow on the ear, hard enough to rupture the membrana tympani, but if great and sudden deafness comes on after a blow on a previously healthy ear, and if it remains for several days without signs of improvement, it must then be adjudged permanent, and the claim for damages must be in accordance with the facts. Even if it should be decided that the injured ear was not in a state of health before the blow, it would seem that all the greater claim could be made by the sufferer. In such a case, however, it must ever be borne in mind that it is not the fissure in the drum-head that has done the damage, but a consequent inflammation in the middle ear, or the concussion of deeper and more delicate nervous parts of the organ of hearing.

MORBID GROWTHS.

Wart-like Bodies on the Membrana Tympani.—Wart-like excrescences on the membrana tympani, first described by Dr. Urbantschitsch,[1] I have observed in but one case. There were in this case, that of a man 24 years old, two pale yellow warts about a millimetre in diameter, on the upper and posterior quadrant of the membrana tympani. There seemed to be no explanation for their occurrence, unless it could be found in the instillation of various fluids, which the patient had practised on his own responsibility, for some time, for the cure of deafness resulting from chronic catarrh of the middle ear. The constant irritation thus applied to the delicate dermoid layer of the drumhead may have provoked the growth of some of its papillæ into the above-named wart-like bodies.

Vascular Tumor, Moles, and Hæmatoma of the Membrana Tympani.—Vascular tumors are not often observed on the membrana tympani. Dr. A. H. Buck[2] observed a vascular tumor in each membrana tympani of a woman sixty-five years old. These were situate in the superior posterior quadrant of the membrana tympani, were soft, mole or tent-shaped, and one millimetre in diameter at their base. Four years ago I observed in the left membrana tympani of a lady fifty-two years old, a brown, flat mole, extending from the membrana flaccida, the short process, and the folds, over the manubrium of the malleus to the umbo, the latter being barely distinguishable. At its upper part the mole was studded with a few short hairs. The hearing was unaffected. Very recently I have seen this case again, and the mole was seen to be unchanged.

Hæmatoma of the membrana tympani has been described by Bürkner[3] as occurring in a pregnant woman. There was also an inflammation in the drum-cavity. Both processes were referred to the great congestion of the head which the pregnant condition induced in this woman. Moos[4] observed a traumatic hæmatoma in the posterior superior quadrant of the membrana tympani of a man forty-two years old, who had been struck on the cheek and helix by a bottle. The hæmatoma gradually moved away backwards toward the periphery.

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[1] Ueber eine eigenthümliche Form von Epithelialauflagerung am Trommelfell, und im aüsseren Gehörgang. A. f. O., Bd. x. S. 7.

[2] American Journal of Otology, vol. iii. p. 282.

[3] Archiv für Ohrenh., Bd. xv. S. 220, 1879.

[4] Ibid., Bd. xv. S. 68, 1879.

Endothelial Cholesteatoma of the Membrana Tympani.—As an antithesis of desquamative inflammation of the middle ear, Dr. Wendt[1] described a new growth, which he called genuine or endothelial cholesteatoma of the membrana tympani. The nature of this new growth is better understood when Dr. Wendt's investigations respecting the membrana propria of the drum-head are known. According to him, this membrane consists of coarse and fine fasciculi; both are inclosed in hyaline tunics, which are very resistant and contain cells of various forms (endothelia). Sometimes the nuclei are unaccompanied by protoplasm, but usually the latter, of round, oval, and stellate form, is present. These forms are subject to change according to the position of the cells. Lymphatics are found in the interstices. Endothelial cholesteatoma was found by Dr. Wendt in the right middle ear of a man who had died of typhus fever. The macroscopic examination revealed the following conditions: "In the anterior inferior part of the inner surface of the membrana tympani, there was found a slightly rough hemispherical mass 1½ mm. in diameter; the transparent golden lustre was characteristic. The lower part of the tumor passed into the membrana tympani, the upper part, hemispherical in shape, projected into the tympanic cavity, and was united to the membrana tympani by a fold of mucous membrane. The growth, after displacing the rete Malpighii, extended outwardly at some points as far as the surface of the external auditory canal; at others it pressed upon the corium of the dermoid layer.

"The mucous membrane of the tympanum was swollen and hyperæmic. The malleus at its anterior surface was detached from the membrana tympani, but still united to it posteriorly. The membrana tympani was flattened and somewhat thickened, it contained several small, round perforations, its layer of epidermis was discolored and broken down, and its mucous layer was swollen and intensely injected."

The microscopic examination of this growth revealed the following: "The tumor is enveloped in a capsule of connective tissue; the latter is loose at some points, stretched at others, runs parallel to the surface of the tumor, contains hæmatoidine, and is covered with cubical epithelium. The capsule covers the outer part of the tumor and that part of it which projects into the tympanum; the lower part passes over into the pathologically altered substantia propria. The capsule is to be regarded as emanating from the mucous layer of the membrana tympani."[1] In the membrana propria numerous cavities filled with parallel and concentrically arranged, nucleated pellicles were found. The trabeculæ were separated by these accumulations. These cavities became larger in the neighborhood of the tumor, in which the trabeculæ ran parallel to the surface of the membrana tympani; they also ran in curves and at various angles. They consisted of extensive fibrils of connective tissue, arranged in fasciculi and inclosed in opaque, cylindrical, nucleated sheaths. These trabeculæ were further united into coarser fasciculi. In the interstices the same pellicles were found as in the membrana propria.

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[1] Archiv f. Heilkunde, 1873, S. 331–362; also abstract by Dr. Trautmann, Archiv f. Ohrenh., Bd. ix. S. 281.

In the upper and older portion of the tumor, numerous crystals of cholestearine and drops of oil lay upon the pellicles, indicating retrograde metamorphosis. The pellicles were found to surround concentrically the coarser trabeculæ; some of the cells of the former were transparent, rhomboid, or crenated in form, and contained an oval nucleus. The above described changes in the membrana tympani are adduced by Dr. Wendt as proof of the endothelial origin of this new growth.

Cholesteatoma of the Membrana Tympani.—Among recent observers Dr. Küpper,[2] of Elberfeld, Germany, has described a small mass which he calls a tumor, found on the membrana tympani of a man 30 years old, who had died of consumption. This small object, 1½ mm. in diameter, was situated below the umbo of the membrana tympani, and was easily removed by simply touching it with a needle. The little mass was pearl gray in color, and composed of several layers arranged like those of an onion. The microscopic examination showed that these were composed of layers of epithelium with here and there some crystals of cholestearine. This could not have been a true tumor. It was simply an aggregation of epithelium, which had undergone cholesteatomatous degeneration. Its occurrence in this case on the membrana tympani was simply fortuitous, judging from the history of the case as given by the observer. The acute desquamative inflammation of the membrana tympani described by some writers, seems to be a myringitis caused by the accumulation, retention, and pressure of epidermis, brought about by the patient's undue efforts at cleansing the ear by picking or swabbing.

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[1] Review by Dr. Trautmann, loc. cit.

[2] Cholesteatom des Trommelfelles. A. f. O., Bd. xi. S. 18.

SECTION V.

MIDDLE EAR.

CHAPTER I.

ACUTE CATARRHAL INFLAMMATION.

ACUTE catarrhal inflammation of the middle ear is a process characterized by an increased formation of mucus, but which stops short of the production of pus. This increased amount of mucus in the middle ear usually escapes through the Eustachian tube, or by absorption; it rarely causes a rupture of the membrana tympani, for the tendency of acute catarrh is rather towards a swelling and a thickening than to a breaking down of tissue.

An acute catarrh of the middle ear, which advances to a perforation of the membrana tympani, will most commonly be found to have led to purulent products, for pure mucus alone is rarely found escaping through a rupture in the drum-membrane.

If, then, an acute catarrhal inflammation of the middle ear advances to the formation of pus, a more destructive form of inflammation, a purulent variety may be said to be present. While the latter condition must always be preceded in the middle ear by the former, catarrhal inflammation may have a distinct existence without the presence of pus.

For the sake of clinical convenience, the endeavor is made to describe two forms of acute inflammation of the middle ear, but the fact must not be lost sight of that very often these so-called forms are but stages of the same disease, and that, therefore, up to the point of succession, *i. e.*, where the *mucous* symptoms are succeeded by the *purulent*, the symptoms and treatment are the same for both forms. In fact all treatment in a case of acute catarrhal inflammation of the middle ear is based on the hope of preventing the formation of pus, which is known to be only too likely to follow the catarrhal or mucous stage.

Symptoms and Course.—The lightest form of acute catarrh of the middle ear comes on during an ordinary cold in the head, or from any other cause which produces only a slight swelling and closure of the Eustachian tube, or congestion in the middle-ear cavity.

In this form it is a congestion and slight swelling of the mucous lining of the Eustachian tube, and perhaps of that of the tympanum, accompanied by an unusual amount of mucus. It may thus affect one or both ears. It causes no pain, in this mild character, and but little hardness of hearing; it brings about rather a stuffed feeling in the ears, with a slightly altered timbre of objective sounds. There is usually some tinnitus, though a slight chronic tinnitus may cease upon the occurrence of a mild tubal catarrh. The patient's voice may be subjectively altered; though this is rare in light cases of catarrh of the ear. The membrana tympani may not even lose its lustre, though its vessels may appear slightly congested, and it may assume, if it is ordinarily transparent, a pinkish hue from the shining through of the congested tympanic vessels.

This form of catarrhal congestion of the middle ear rarely troubles the patient, and therefore receives very little attention. It may disappear as rapidly as it came, in the course of a day, without any treatment.

That form, however, characterized chiefly by pain, hardness of hearing, autophony, and subjective noises in the ear, is not only more annoying to the patient, but demands prompt treatment. It comes on usually after exposure to cold; but it may be caused by various diseases involving the mucous membrane of the nose, mouth, throat, and nasopharynx, as syphilis, various continued fevers, and the exanthemata.

Acute catarrh is more likely to affect one ear than both, and is apt to come on in an ear already affected by chronic catarrhal disease.

Pain.—The pain is not as severe as that of purulent inflammation of the middle ear, and this is perhaps the chief early diagnostic point between the two diseases. The pain, usually darting only from throat to ear, may become sharp and boring and not limited to the ear. It is then very apt to follow the varied course of the fifth cranial nerve, and in this phase is not unfrequently mistaken for neuralgia both by patient and physician.

It intermits during the day, growing worse at night, but never becomes as intense and unendurable as the pain of acute purulent otitis. It is often more a sensation of great fulness than true pain. Fever is rarely present, and the cerebral symptoms are by no means grave; unless, of course, the aural disease accompanies or is caused by a febrile disease.

The pain is caused primarily by the inflammation of the mucous membrane, but it is aggravated and kept up by the results of the inflammation, *i. e.*, by the swelling of the mucous membrane and by the increased amount of secretion.

The first acts by diminishing the size of the cavity of the middle ear and closing the Eustachian tube, by which means the air is excluded from the tympanic cavity, and the products of inflammation cause pain by directly pressing on the inflamed mucous lining of the tympanum, tympanic plexus, and upon the membrana tympani.

Vacuum formed in the Tympanum.—If the faucial mouth of the Eustachian tube becomes swollen and blocked up with mucus, the tympanic cavity is deprived of its proper ventilation, the air which was in the cavity at the beginning of the tubal catarrh becomes absorbed, and, since no fresh supply of air can get through the swollen tube, a vacuum is formed in the cavity of the drum. This condition alone tends to produce pain; in children, it is often the only cause of pain in acute catarrh of the tube and tympanum, for, the external atmospheric pressure remaining constant, the membrana tympani is forced inward, carrying with it the chain of ossicles. A continuance of the vacuum may lead not only to a great extravasation from the tympanic vessels, but even to their rupture. Hence, it is not uncommon to find true ecchymosis on the membrana tympani, after the Eustachian tube has been closed for some hours, in a case of acute aural catarrh. In some such way we may account for the rare cases of so-called otitis media hæmorrhagica, to be referred to hereafter.

Pain increased by talking, coughing, sneezing, and eructation.—This is a prominent feature of acute aural catarrh, in which the faucial mouth of the Eustachian tube is always affected. It is due, partly, to the muscular movements beneath the inflamed mucous membrane, and also to the direct effects of the forcibly expired air upon the inflamed lining of the tube and tympanum, before secretion has taken place. According to investigations of Lucæ,[1] it seems highly probable that, at each expiration, the air in the nasopharyngeal space is condensed, and hence pushed into the more or less normally patulous Eustachian tube.

No one symptom in acute aural catarrh is so universally spoken of by patients, as the painful effect of eructation. It is very common, indeed, for this to be complained of, as the only symptom in cases of congestion in either a previously perfectly healthy tube, or during an intercurrent acute congestion in a chronic aural catarrh. Patients under treatment for the latter will, upon changes in the weather, complain of the above symptoms.

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[1] Virchow's Archiv, Band lxiv., Zur Function der tuba Eustachii und des Gaumensegels.

As those affected with chronic aural catarrh are also very apt to have a slight paresis of the velum, which prevents its being able perfectly to close the upper from the lower pharynx, it would seem that sudden eructations or any forcible expiration may be all the more likely to strike against the pharyngeal mouth of the Eustachian tube, and, in some cases, even penetrate into the tympanic cavity.

Both Senac and Tissot[1] observed difficulty in swallowing in cases of earache, which the former attributed to sympathy (consensus) between the pharynx and the ear, but which the latter observes "is connected with a slight inflammation of certain of the muscles of deglutition." I have observed in my own case that when the faucial mouth of the Eustachian tube is slightly swollen, *i. e.*, when, with a slight cold in the head, the tube does not become readily patulous on swallowing, a slight touch of the finger in the external auditory canal produces an intense tickling in the fauces high up behind the velum, and I am forced to cough. This peculiar sensibility does not exist in my ear when the Eustachian tube is unaffected, but probably every observer knows, as the author does, of many persons in whom the gentlest touch of the finger upon the mouth of the auditory canal will almost always bring about this peculiar dry cough, called ear-cough. (See p. 311.) I have observed that children whose ears are perfectly healthy, as well as those whose ears are more or less diseased, are especially susceptible to this reflex cough. I have seen infants exhibit marked ear-cough upon their mothers most gently touching the concha or brushing some small object from the vicinity of the mouth of the external auditory canal. But even those of any age in whom this reflex cough is found, are not always equally sensitive, for it is more easily produced at one time than at another. It is, on the whole, most likely to attend some morbid condition of the ear, and I have seen it often in cases of acute catarrh of all grades.

Hardness of Hearing.—The hardness of hearing is caused chiefly by the swelling of the mucous membrane and the collection of mucus and extravasated serum in the tympanic cavity. These alterations in the tympanum interfere with the vibratory motions of the auditory ossicles, the former by a direct stiffening of all their joints, and the latter by loading not only the ossicles but the fenestræ. Hence, hardness of hearing is most marked after secretion has taken place. At the onset of the inflammation the hearing may be morbidly acute. A secondary implication of the labyrinth by an extension of inflammation or congestion from the tympanum very probably often occurs, and tends further to impair the hearing. Throughout this disease the resonance of the patient's voice is liable to annoying subjective alterations, most probably due to the altered condition of the Eustachian tube.

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[1] Traité des Nerfs et de leurs Maladies, Paris et Londres, 1780, p. 54.

Tinnitus Aurium.—This is one of the chief symptoms of acute aural catarrh. It is caused principally by the altered circulation in the tympanum, and seems to become more aggravated as the inflammation advances. It resembles, very often, painfully high musical notes, and is one of the most distressing symptoms, being complained of almost as much as the pain. Tinnitus is of the constant variety, *i. e.*, unaffected by the pulsation, in simple catarrh; when the inflammation becomes more severe, and purulent symptoms supervene, then, in some cases, the tinnitus becomes interrupted by the pulsations, and each heartbeat is felt in the ear most painfully. The tinnitus of acute catarrh is referred rather to the ear than the entire head; the latter variety seems to indicate severer inflammation. Subjective noises may be entirely unmusical in their sound, resembling merely a crackling of mucus or the bursting of bubbles of a tenacious substance. This kind of noise in the ear would seem to be not very difficult of explanation, and should be referred to the movements in the mucus in the middle ear. It is, of course, characteristic of a late stage.

It may, therefore, be concluded that tinnitus aurium is due to what are best termed *morbid vibrations* originating in the various parts of the organ of hearing, *i. e.*, they have truly an *objective* existence in the *subject*. That a morbid circulation of the blood, let us say a too rapid flow of it, through the temporal artery may cause tinnitus aurium, I know by personal experience, and I also am fully aware that such a form of tinnitus may be quelled by pressure over that artery just in front of the tragus.

Tinnitus may be also relieved by gentle pressure over the carotids. Such facts would tend to show that the blood may throw the vessels of the ear into such morbid vibrations that the latter are interpreted by the ear as sounds. If sound is motion, what can be more reasonable than such an explanation?

Tinnitus aurium, in general, may be explained by the "vascular theory" of Theobald.[1] At the outset in this theory a subjective sensation is to be regarded as having no imaginary but a real existence, and, therefore, tinnitus aurium has a real existence, being due to morbid vibrations produced in the vessels of the internal ear and then communicated to the nerve. Two modes whereby vibrations of the vessels of the labyrinth may be enabled to produce a sensible impression upon the auditory nerve are suggested by Dr. Theobald, viz.: 1. The amplitude of the vibrations may be increased; 2. The vibrations remaining unaltered, their effect upon the nerve may be magnified, either by reflection and concentration, or by resonance.

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[1] Tinnitus Aurium, a consideration of the causes upon which it depends and an attempt to explain its production in accordance with physical principles; Samuel Theobald, M.D., Baltimore, 1875.

The first condition may be said to exist whenever an undue amount of friction attends the movements of the blood. "This will happen when the normal relationship between the intra-vascular and the intra-labyrinthine pressure is disturbed, or when, in any other way, the natural and easy flow of the blood is perturbed, as, for instance, in hyperæmia or anæmia of the labyrinth vessels, increased or diminished intra-labyrinthine tension, partial compression or obstruction of the trunks of the vessels by inflammatory or other causes, and finally, when the constitution of the blood itself is altered, as in spanæmia or chlorosis. The tinnitus which is known to occur in increased labyrinthine pressure is attributed "to the accompanying vascular disturbance, rather than regarded as the expression of an irritation of the nerve, the immediate result of compression."

Tinnitus aurium occurring in diseases of the middle and external ear, unaccompanied by pressure in the labyrinth, may be referred to the defect in the sound-conducting apparatus. Whenever waves of sound cannot, from without, obtain normal admission to the percipient parts of the ear, tinnitus aurium may also be referred to the same kind of obstruction, since conditions of the sound-conducting apparatus which prohibit the entrance of sounds from without will also prevent their escape from within, and this will magnify their effect upon the nerve, or increase their loudness. The well-known fact that tinnitus aurium is not often complained of when a perforation in the membrana tympani exists, is explained by Theobald as due to the ready escape thus offered to the vibrations occurring in the ear.

The probability of the origin of tinnitus in this way is increased by the fact that just the notes of high pitch which these delicate vascular vibrations would make, would correspond to the generally high quality of subjective noises in the ear.

Dr. Blake[1] has shown that notes of tuning-forks which give an extremely high number of vibrations per second are heard much more easily when the membrana tympani is perforated, that is, they gain access to the auditory nerve more readily. This being undoubtedly the case, as shown by Blake's experiments, Theobald is apparently fully justified in his theory as to the ready escape of high tones originating in the vascular movements of the labyrinth, which might be interpreted by the ear as tinnitus, did they not readily escape through the perforation in the membrana tympani.

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[1] Transactions American Otological Society, vol. i. p. 438.

The ordinary normal vascular movements in the labyrinth are not productive of tinnitus aurium, because a normal ear permits the escape of all vibrations produced by ordinary vascular movements in the ear, without perceiving them as sound.

That motions sufficient to produce sound are constantly going on in the ear, which, however, the latter fails to hear, in the normal correlation of forces obtaining in the healthy organ, is proven by gently stopping a normal ear, whereupon tinnitus of varied pitch may be perceived.

This, as has already been said, is due to the altered resonance and reflection brought about in the ear by the stoppage of the meatus with the finger; for that which prevents sounds, *i. e.*, vibrations, from entering the ear will also prevent the escape of those originating in the ear, and thus the ear hears the so-called subjective sounds.

Autophony.—The subjects of acute aural catarrh often complain of hearing their own voices disagreeably or even painfully in the affected organ. They liken this sensation to that experienced by one speaking in a closet, or with one's head in a barrel. This altered resonance of one's voice is termed autophony. It is not a symptom entirely of disease of the middle ear, as it may be experienced in a disease of the external ear. It is due to the obstruction offered by the swollen aural tissues to the ready egress of vocal sounds from the ear, which in a state of health permits a normal, and hence unconscious, transmission of sounds both to and from it. Disease of the middle ear especially interferes with the ready normal transmission of the vocal sounds of the patient, and autophony is the result. Autophony can be produced artificially by the introduction of the finger into the external auditory meatus. Sexton[1] explains autophony as due to the fact that the vocal sounds instead of being heard from the mouth through the external air and then by the drum, are, in some cases of aural disease, made to gain access to the nerve of hearing by traversing the tissues between the mouth and the ear in a more or less direct line, thus being heard *false* in comparison with normal hearing. Altered resonance in the ear, especially in the musically educated, may be characterized by a variety of hyperæsthetic and varied phenomena of subjective sounds.

Altered resonance is experienced by musicians, not only in their own voices, but also in the instruments on which they perform. The latter seem to give forth incorrect notes.

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[1] New York Med. Record, Jan. 22, 1881.

Double Hearing or Subjective Echo-like Sensation; Paracusis Duplicata; Subjective Alteration in Pitch.—Double hearing, or a subjective echo-like perception of tones or words spoken by or to the patient, may be connected with acute catarrh of the middle ear.

Generally the latter part of the word is thus perceived; it seems to be higher in pitch, as I can testify by observation of this phenomenon in my right ear. During a slight catarrhal closure of the Eustachian tube without pain, I have heard a disagreeable echo of the last syllables of words in my right ear. The tones of the syllables thus perceived were certainly higher in pitch than the word as spoken to me. How great this sharping was, I cannot state. The notes of the piano did not seem to me to be thus sharped, nor were they subjectively echoed in their true pitch.

In some cases both words and musical notes are perceived in this peculiar echo-like way, without alteration in pitch; this is more likely to be the case with words than with musical tones. The latter are usually sharped a half tone or more.

Some of the earliest accounts of this phenomenon are those of Sauvages, Itard, and von Gumpert;[1] the same symptom has been noted by von Troeltsch and Politzer. The cases of Sauvages and Itard were observed in patients suffering with catarrh of the middle ear. Von Gumpert observed the phenomenon on himself. The subjective difference in the note varied between the third, the fourth, and the octave. He also perceived the echo-like ending of words. The peculiarity lasted for a week.

Von Wittich,[2] too, observed most carefully a similar alteration in his own hearing, four weeks after an inflammation in his ear. "The notes of a tuning-fork appeared exactly a half tone higher in the diseased ear than in the well one. The same was perceived respecting notes of the middle scale, either when whistled or struck on the piano. They were heard *double*, the difference between the two ears being a half tone."

"This phenomenon remained unaltered, both when the external auditory canal on the affected side was filled with water or cotton-wool, and when by inflation the membrana tympani was made to change its tension. Apparently, a somewhat different phenomenon presented itself when a vibrating tuning-fork was placed on the teeth, for the natural tone was heard gradually to die away into the next half tone higher."

In the latter instance there was apparently a double hearing, or an after-hearing of the true note sharped, in the diseased ear.

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[1] Quoted by Bressler: Die Krankheiten des Kopfes und der Sinnesorgane, Berlin, 1840, Bd. ii. S. 375. See Moos and Gruber.

[2] Königsberg Med. Jahrbücher. Bd. iii., 1861.

When the fork was placed on the vertex, the tone appeared higher the nearer it was to the affected ear. Two forks, one of which was a half a tone higher than the other, were heard as the same note, when the higher was held before the well ear and the lower before the diseased ear.

Sir Everard Home[1] has related the case of an eminent music teacher, who, after taking cold, perceived, in addition to confusion of sounds in his ears, that the pitch of one ear was half a note lower than that of the other; and also that the perception of a simple sound did not reach both ears at the same time, but seemed as two distinct sounds following each other in quick succession, the latter being the lower and weaker.

This phenomenon was considered by Home to be due to defective action in the muscular structures governing the tension of the membrana tympani, although it is evident he was entirely unacquainted with the structure of the membrane, since he described as he thought a radiate muscle lying in the drumhead, whereas no such structure exists as part of its layers. But that he has accurately described a case of double hearing and subjective alterations in pitch, is beyond doubt.

Moos[2] relates two cases: one, that of a tenor singer who, for fourteen days after a severe coryza, heard simultaneously the treble of all the notes he sang. This was found to be due to catarrh of the middle ear and some hardness of hearing on both sides.

The same author gives an account of double hearing in a case of chronic catarrh of the middle ear. In this instance the phenomenon of double hearing came on after the patient used chloroform for relief from an attack of asthma. Immediately after the narcosis the hearing was worse, subjective noises of various descriptions were perceived, and the patient noticed that all notes from a′ up were heard double in both ears. Later the notes thus doubled were e″ and all notes from that point up the scale.

These subjective phenomena of hearing can be ascribed to the exacerbation of catarrh produced by the breathing of the chloroform.

Gruber[3] has noted the phenomenon in two cases: in one case, that of a musician, a musical note was heard a third higher. In some instances the after-sound may be of the same pitch as the original note.

Perhaps this phenomenon, double hearing, would be noted more frequently if the patients were generally educated in music, for it is worthy of note that in the cases recorded the sufferers were musical.

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[1] Philosophical Transactions, Royal Society of London, Part I., 1800.

[2] Klinik d. Ohrenheilkunde, pp. 319, 320, 1866.

[3] Op. cit., p. 626.

CASE I. The first instance of double hearing, or, as I prefer to call it, subjective alteration of pitch, which I observed, was in a young Austrian officer of good musical education, an amateur performer on the violin. During an acute otitis media on the left side, he noticed that in tuning his violin the note appeared a third higher in the affected than in the normal ear. This condition lasted for several days, but disappeared with the cessation of the acute disease of the ear.

In this case the hearing could be called double in the sense that the normal ear heard the true note and the diseased ear another, viz., one apparently higher than the original note, producing subjective confusion.

CASE II. In this case the subjective alteration in pitch occurred in both ears. During a successful treatment for chronic purulent disease of both ears, the patient, a young woman of 23, music teacher, suffered from a slight intercurrent acute otitis media on both sides. All sounds became disagreeable, and she especially noted and complained of a sharping of all musical tones of the voice of others in singing and of the notes on the piano. This, however, disappeared in a week, and the purulent disease was finally cured. The hearing in this case became almost normal after the disappearance of the suppurative disease of the middle ears.

In this second case it could hardly be said the patient suffered from double hearing, for she heard a similar subjective sharping of piano-notes in both ears. This she knew to be the case, not by discord, but by her knowledge of music, for she knew, when she struck a given note on the piano, that the note her ears perceived in their diseased state was sharper than the note she heard when the same key was struck by her in health.

Intra-tympanic Pressure during Phonation.—Under normal conditions, phonation produces variations in pressure both in the mouth and nasopharyngeal space. It is greatest with some consonant sounds. Experiments of Dr. C. J. Blake[1] show that this pressure is sufficient to be communicated to the tympanic cavity through the Eustachian tube. This pressure may become painful in some cases of disease of the middle ear. In such instances the patient may voluntarily avoid pronouncing the nasal consonant sounds m, n, and ng, since the pressure in the tympanum, brought about by their phonation, is painful.

The sensations produced by their pronunciation has been described as a disagreeable cracking and bursting sound, least so with m; most so with ng. In a case of this kind observed by Dr. Blake, a cicatrix in the membrana tympani was seen to make vibrations with each of the above consonant sounds; least with m, a larger one with n, and "with ng a double excursion was observed, the membrane only partially resuming its original position between the two movements." All of these unpleasant symptoms were relieved by excision of a portion of the flaccid cicatrix. A round opening was thus made, the symptoms above named disappeared, and the patient articulated normally. Dr. Blake also found that a manometric column of water (diam. 1 mm.) connected with the meatus, when m was pronounced, rose and fell ½ mm.; with n, nearly 1 mm.; and with ng, a double rise and fall of nearly the same degree was observed.

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[1] Intra-tympanic Pressure during Phonation, Trans. Amer. Otol. Soc., vol ii. p. 75, 1875.

Recurrence, every year for fourteen years, of a Peculiar Subjective Noise and Altered Resonance of Voice, in the Left Ear; Temporarily relieved by Pressure on the Auricle and Meatus.—September 9, 1873, Mrs. C., 35 years old, living in affluence, states that for fourteen years she has experienced an altered resonance of her voice and some buzzing noise in the left ear, which come on together in June, with the warm weather, and last until September. She also makes the strange statement that these subjective alterations become apparent to her toward midday and last until about bedtime. She can always gain relief for a few moments by pressing and pushing the auricle and meatus on the affected side, but as soon thereafter as she swallows, the altered resonance returns. The hearing remains unaltered and certainly appears perfect on testing. The voices of others are never changed in quality as her own is. She says she has, in winter, catarrh of the throat, at which time there is more or less soreness confined to the Eustachian region on the side where these peculiar alterations occur in the summer season.

In winter, however, these subjective alterations have never occurred. Examination revealed a follicular pharyngitis without hypersecretion.

The membrana tympani was normal in every respect, except in its being a little more indrawn than its fellow. The tuning-fork placed on the top of the head was heard equally well in both ears. The Eustachian tubes were readily pervious to air from Politzer's bag. As the statements concerning these peculiar subjective symptoms in the left ear are to be credited, there are several points of great interest which earnestly demand some explanation. 1. The occurrence of these peculiar symptoms in summer-time only. 2. Their coming on towards midday and passing off towards bedtime, *i. e.*, about 9–10 P.M. 3. The temporary relief gained by pressing on the auricle and in the meatus. 4. Their instantaneous return on swallowing.

Naturally the mind connects their causation with summer and its heat, which idea is only strengthened by the statement that they grew worse as the day grew warmer, and disappeared as the sun went down and the temperature fell.

The chief cause of this subjective alteration in the ear must be sought in the condition of the Eustachian tube.

It is not uncommon to find the nasal mucous membrane subject to an irritability from the heat of summer; it, therefore, seems fair to presume that the same irritability—a kind of erectility—may exist around the faucial end of the Eustachian tube. Let us suppose then that the heat of summer caused in this case a swelling in the tube in the manner suggested above; at the same time, it expanded the air locked up in the tympanum by the closure of the mouth of the Eustachian tube.

The expansion of the air contained in the tympanum forced the membrana tympani outward, and unlocked the malleo-incudal joint. This disturbed the equilibrium of these parts and brought about very much such an altered resonance as any one experiences after blowing the nose during an ordinary nasal and faucial catarrh.

This pushing outward of the membrana tympani was sustained by the expanded air of the tympanum until the patient pushed the auricle and pressed the finger-end into the meatus. Then the column of air in the external auditory canal, being condensed by the pressure from the finger-tip, forced the membrana tympani inward. The latter, in turn, pushed some of the expanded air of the drum-cavity out through the slightly swollen Eustachian tube, and resumed, with the ossicula, a position of equilibrium, and then vibrated normally until an act of swallowing occurred. Then the altered resonance returned.

The return of the peculiar subjective resonance after the act of swallowing can be explained thus: The first effect of swallowing is to open the Eustachian tube, and to force air into the drum-cavity. But in the normal, loosely closing, or closed tube, more than the requisite amount of air recoils, and the equilibrium is maintained in the tympanum. In this case the tube was enough swollen to interfere with the recoil of a surplus of air which it was obliged to permit to enter the drum-cavity at the relatively powerful act of swallowing. According to Lucæ, so powerful is this act, and so great is the amount of air forced into the tympanum by it, that the first effect in the latter cavity is one of condensation. In this case the tube was not so much swollen as not to permit the usual large amount of air to enter the tympanum at swallowing, but it was enough irritated and narrowed by the effects of heat to interfere with the ready recoil of the surplus of air forced into the drum-cavity by swallowing; hence too much air remained in the tympanum, the equilibrium remained disturbed, and the peculiar resonance became once more apparent, until the finger forced the membrana tympani back to a normal position.

Acute Aural Catarrh in Infants and Young Children.— Since this disease constitutes much of the so-called earache in little children, it will be well to bestow more than ordinary comment on its occurrence in them. Unfortunately it is a disease too commonly overlooked in them, partly on account of their inability to locate their pain and communicate their feelings to others, and also on account of the difficulty of examining young and suffering infants. Hence the disease may escape proper treatment, and lead finally to permanent injury of hearing, and even to results fatal to life if allowed to pass into the purulent form of tympanic inflammation. This disease of the ear is apt to come on with catarrh of the air-passages, teething, whooping-cough, and the exanthemata. Its most common occurrence is during a cold. If it occur in an infant, the little victim will suddenly cry out most piteously, at first only with every severer twinge of the increasing pain, but at last it wlll utter a quick succession of piteous and peculiar shrieks. This cry has been said to resemble that occurring in acute bowel-disease, and has often been mistaken for that in infants. But the continuance of the pain, despite the treatment directed to the bowels, will soon show the careful observer that the disease is not in the intestines. The infant will refuse all nourishment, the breast or the bottle is pushed away, and if the nurse now endeavors to dandle the little sufferer, each movement will cause it to shriek more loudly, and convulsions may supervene. In an older child the cries may be so dreadful that isolation of the patient in a remote part of the house becomes necessary in order not to alarm its relatives and neighbors. Such severe forms usually terminate in suppuration.

Very frequently, attacks of earache from acute aural catarrh come on only at night, for several nights in succession, but in the intervening daytime the little patient plays about as usual. If the ear is examined in such cases, the membrana tympani will be found greatly drawn in and lustreless, looking like ground glass, or a polished steel surface just breathed upon. The manubrium of the malleus in such cases is so much retracted and foreshortened, that it will appear far up and behind in the posterior superior quadrant of the drum-head. The membrane may appear congested about the malleus and its folds. It must be remembered that in infants, and very young children under six years of age, the membrana tympani occupies, normally, a position much more horizontal than in older children and adults (see p. 50).

These cases are primarily and emphatically *tubal catarrh*, with more or less hyperæmic swelling of the lining mucous membrane of the tympanic cavity.

The pain is aggravated at night, especially by the recumbent position, which, of course, increases the congestion and swelling, both in the tube and tympanum. Thus, the vacuum already alluded to is made greater, and the external air presses with greater force on the outer surface of the membrana tympani, forcing the latter inward, and with it the chain of ossicles. The freedom from pain in the daytime is due to a partial subsidence of swelling in the tube and tympanun, and consequently to less of a forcing inward of the membrana tympani and the ossicles. A want of air in the tympanic cavity is, therefore, one of the chief causes of pain in these cases of acute catarrh of the ear; and hence, sneezing, blowing the nose, or an artificial inflation of the tympanum will usually cause a cessation of the pain, by overcoming the vacuum in the tympanic cavity and thus relieving the undue tension of the drum-membrane.

In very young children, a high degree of deafness may be present from merely a persistent simple catarrhal process in the Eustachian tube. If the latter is opened, usually by one good inflation with Politzer's air-bag, the hearing is instantly greatly improved, and a few repetitions, every other day, of this manipulation will effect an entire cure of the case. But such cases, I believe, are rarely recognized soon enough for beneficial treatment. Yet, I have seen enough of them to lead me to conclude that many cases of chronic deafness, in those just arriving at the age of puberty, are attributable solely to neglect of simple catarrh of the tube four or five years previously. In such cases the closure of the Eustachian tube, especially if it be on only one side, is either not noticed by the patient or his friends, or, if noticed, is neglected, in the hope that the child will outgrow the trouble: and it appears that sometimes it does, by a spontaneous opening of the tube. Usually, however, the tube being closed for a long time and the tympanum deprived of air, the latter loses, often irretrievably, its function of permeability, just as an air-sac in the lung would, beyond a stopped-up bronchial tubule.

Acute aural catarrh in larger children is usually the result of undue exposure to dampness and cold. Although these attacks of acute catarrhal inflammation of the middle ear, from imprudent exposure to cold, are both common and painful, they are not usually as likely to become chronic, and thus permanently injure the hearing, as those forms of aural inflammation brought on by the exanthemata. The latter usually lead to purulent inflammation and spontaneous rupture of the membrana tympani, but acute catarrh may run a painful course, without producing spontaneous rupture of the drum-membrane. In fact, this tendency to produce a spontaneous rupture of the drum-head, or not, is one of the distinguishing marks between acute purulent and acute catarrhal inflammation of the middle ear.

The large majority of all cases of chronic purulent inflammation of the middle ear, are unhesitatingly attributed by the patients to the exanthemata or to some of the continued fevers. If the purulent discharge is said to be the result of earache from cold, it is usually found to date back to earliest infancy. Another equally striking fact is that chronic aural catarrh, *i. e.*, oft-returning and slowly increasing hardness of hearing, is almost invariably attributed to, or at least said to be aggravated by, cold in the head. It may be that inflammation of the middle ear, caused by cold in the head or acute inflammation of the air-passages, is of a sthenic type, while that produced by blood-poisoning of any kind, like the exanthemata, continued fevers, syphilis, etc., is of a decidedly asthenic type, tending to destruction of tissue.

Objective Symptoms in Acute Catarrh of the Middle Ear.—If the membrana tympani can be examined in the first stages of this disease, there will be noted, first, a slight congestion about the periphery of the membrane, with a somewhat greater amount in the membrana flaccida and in the vessels lying over the handle of the malleus. The color of the membrana tympani, in general, will not be much altered at first, but its lustre may be slightly dimmed, and the pyramid of light will become faint or fade entirely. In many cases, even in those with considerable accumulation of mucus in the tympanum, the membrana tympani will not lose its contour, as it does in the purulent form of otitis media. A marked objective symptom, however, is the retraction of the membrana tympani.

Retraction of the Membrana Tympani.—The retraction of the membrana tympani may be so great in these cases, on account of the exhaustion of air from the tympanic cavity, that mucus in quite large quantities may be present without causing any bulging of the drum-head. In such cases, however, unless the drum-head is very thick, the mucus can be seen through the delicate membrane; the color of the latter will then be influenced by that of the mucus in the tympanic cavity, and the surface of the membrana tympani may finally be made to bulge, either in spots, by lumps of mucus, or regularly at some one segment, mostly the hinder, by a more homogeneous kind of mucus. If the fluid in the drum-cavity is serous, bubbles can be easily seen in it through the membrana tympani.

Spontaneous Rupture of the Membrana Tympani.—Spontaneous rupture of the membrana tympani is rare in simple acute catarrhal inflammation of the middle ear. I consider this the chief diagnostic point between this disease and acute purulent inflammation of the middle ear, to which, I grant, the acute catarrh is only too likely to lead. But since, as a matter of fact, we rarely find purely mucous products breaking down the membrana tympani and discharging themselves through the opening thus made, while we constantly find pus escaping in this manner, I am forced to conclude that acute catarrhal inflammation leads rather to a thickening of tissue than to the more destructive disease—acute purulent inflammation of the mucous lining of the middle ear. In the latter instance we invariably find purulent discharge escaping from one or more spontaneous ruptures in the membrana tympani. The same view was entertained by Rau,[1] who states that the results of inflammation, comprehended "under perforation of the membrana tympani, destruction of the ossicles of hearing, caries of the mastoid," etc., do not follow acute catarrhal inflammation of the ear, but are results of the acute purulent form of aural disease.

I observed, not long since, in a medical man, 60 years old, just recovering from pneumonia, an apparent exception to what seems the rule, that pure mucus is never found escaping through a spontaneous opening in the membrana tympani. A little pain, with considerable dulness of hearing, were the first symptoms. These were noted by the patient some days before the membrana tympani was examined. I found the membrana tympani uniformly pinkish and thick in appearance, lustreless, and bulging in its entire posterior half; the position of the malleus plainly visible. Paracentesis of the drum-membrane was proposed, but not performed at request of patient; and that night and the next morning jelly-like, transparent mucus, resembling thick white of egg, came from the tympanum through a spontaneous opening in the drum-membrane. This perforation healed in a day. Although this case was complicated finally by a deep-seated abscess of the cellular tissue over the mastoid portion, the hearing was fully restored. The membrana tympani now shows a small, grayish spot in the posterior segment where the opening occurred.

In addition to the chief symptoms, fulness and pain in the ear, with hardness of hearing and tinnitus aurium, we shall find, usually, in acute catarrh of the ear, general catarrhal symptoms of sore throat, cold in the head, cough and hoarseness, and some headache; but vertigo and fever are not common attendants of this disease. The latter symptoms are usually proportioned to the severity of the pain. As a rule, all the symptoms of acute aural catarrh will be found abating with the cessation of the general catarrhal symptoms, excepting, perhaps, the deafness, which may increase with the general increase of local secretion from the various parts of the mucous tract implicated in the general catarrh. This increase in the deafness is, of course, due to the mechanical obstruction in the Eustachian tube and tympanic cavity, brought about by the large amount of thick mucus retained in the middle ear, by the swelling of its mucous lining. The latter may be kept up by additional attacks of slight catarrhal swelling.

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[1] Ohrenheilkunde, sec. 195.

Course.—This affection may lead rapidly to purulent inflammation of the middle ear. It is not, however, the more violent form, either in children or adults, which leads to permanent deafness. The oft-recurring, slight attacks of fulness in the ears, with every cold in the head, are most likely to lead to a chronic catarrhal swelling and deafness. Such cases finally cause an accumulation of inspissated mucus in the tympanic cavity, according to some observers (Hinton). My experience would lead me to believe that such accumulations are not as common in this country as they appear to be in England, if we may judge from the writings of the late Mr. Hinton. Be this as it may, respecting the slow and chronic accumulations of inspissated mucus, it is very certain that the oft-recurring stuffed feeling in the ears, with every cold in the head, usually leads to permanent changes in the hearing unless relieved by proper treatment.

Etiology.—Acute catarrh of the middle ear is most apt to occur in the spring and autumn, or in changeable weather in midwinter, and is usually found whenever catarrh of the air-passages is prevalent. It is also caused by teething, whooping-cough, continued fevers, the exanthemata, and syphilis. In summer-time there are two great causes for its occurrence, viz., cold bathing and diving, and sitting in a draught of air to cool the heated body. In the first instance, the exposure of the ear to breakers or to the cold water in diving, is the cause of the inflammation. This is easily understood when one reflects that the membrana tympani is so thin that its mucous surface is practically brought into direct contact with the cold water whenever the latter enters the external auditory canal, as in diving, or by any other incautious means of submerging the head. It would seem that in such cases the inflammation of the tympanic cavity is secondary to a myringitis produced by the cold water. Strangling, often induced in diving, may lead to the introduction of cold water through the Eustachian tube into the middle ear, and thus produce inflammation of the tympanic mucous membrane. In the second instance, when inflammation of the middle ear comes on after cooling off in a draught of air, it seems to be the result of a general constitutional disturbance due to the exposure of the heated cutaneous surface to cold air, and the result is similar to a chilling of the surface of the body in winter, when, as is well known, the aural disease is often joined to sore throat and coryza, all of which are due to the same atmospheric or telluric cause.

Many cases of catarrhal inflammation of the tympanic cavity may be said to be to a great extent mechanical in their origin. The catarrh of the Eustachian tube closes up that important communication between the tympanum and the fauces, causing a vacuum and a retention of mucus in the drum-cavity. Consequently an irritation is set up there, both by the want of air in the drum and a slow decomposition of the retained tympanic excretions. Hence many an acute catarrhal process in the tympanic cavity, accompanied even by pain, may be cut short by one or two good inflations by means of Politzer's air-bag. A great many cases of acute catarrh of the middle ear are produced by sudden exposure to the air after all forms of vapor baths. The heroic Turkish and Russian baths, so largely advertised, are constantly producing acute catarrh of the ear. The same evil result is often due to "cold packing" in water-cure establishments.

Earache from Teething.—Earache occurs very often in teething; so frequently is it an attendant of this period of childhood that I have known mothers to prophesy with accuracy the coming through of a new tooth, from the sudden attack of earache. The vast majority of these cases never pass beyond the simple catarrhal form. This peculiar connection between teething and earache was also noted by Rau.[1]

In some instances we may find that the catarrhal inflammation has passed into the acute purulent form of tympanic inflammation, attended by perforation of the membrana tympani and discharge of puriform matter.

The tendency to inflammation of the ear in teething is favored by the nervous connection between the teeth and the vascular supply of the ear. The middle-ear cavity is supplied by the tympanic branch of the internal carotid artery, which anastomoses with the tympanic branch of the internal maxillary and stylo-mastoid arteries, branches from the external carotid. The tympanic branch of the internal carotid artery passes directly from the latter to the tympanic cavity. Hence, any congestive effect on this vessel must be quickly and largely felt in the ear. Dilatation of this branch is brought about rapidly by any inhibitory force brought to bear upon its vaso-motor nerves. Such a force is supplied in the irritation from inflamed gums in infants. For, since the carotid plexus and the inferior dental nerve are both supplied by branches of the otic ganglion, irritation communicated to the ganglion from the teeth must be felt in the vaso-motor nerves originating from it. The effect of such an irritation is to inhibit the vaso-motor nerves governing the calibre of the tympanic artery alluded to. It then becomes dilated, and the parts of the ear it supplies engorged. Congestion, inflammation, and suppuration may then ensue. This inflammatory action may be communicated quickly from the middle ear, in young children, through the petrosquamosal fissure to the brain. It is thus shown how convulsions, meningitis, and death occur in infants in connection with teething.

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[1] Ohrenheilkunde, sec. 168.

Earache in Whooping-cough.—Whooping-cough is not an uncommon cause of acute catarrh of the middle ear; the perforation of the membrana tympani occurring in these cases may be due to the mechanical force of the cough, and not merely to spontaneous results from the catarrhal disease. Without doubt, the inflammation in the tympanum weakens the lining of the cavity and favors its easy rupture by the force of coughing. The intimate relation between the ear and the pneumogastric nerve must not be forgotten as a causal element in ear disease occurring in pertussis.

Diagnosis.—The diagnosis of acute catarrh of the middle ear will be aided, chiefly, by the comparatively slight pain, the marked hardness of hearing, and the annoying hissing tinnitus, and, in a minor degree, by the presence of other catarrhal symptoms, such as sore throat, cough, etc., with little or no fever, nor any marked constitutional disturbance. It will also be noted that the pain is more easily overcome than the hardness of hearing, and that there is no tendency to a spontaneous rupture of the membrana tympani. When the patient inflates his ear, or when it is inflated artificially by the surgeon, loud mucous râles will be heard in it. These are audible in a marked degree to the patient, and easily heard by the surgeon's ear, when assisted by the auscultting tube.

Objectively, the diagnosis will be aided by careful inspection of the membrana tympani. The latter will be found to present the varying appearances already described, according to the stage of the disease. At times it may be noted, with surprise, that the membrana tympani has not undergone great objective changes, notwithstanding the marked subjective symptoms in acute catarrh.

If the secretion of mucus has been large, and consequently the deafness of a high degree, usually it will be seen that the membrana tympani is forced to bulge from the pressure of the retained mucus in the tympanic cavity. Another important aid in diagnosis is the freedom of the auricle and auditory canal from inflammation. These may be handled without pain to the patient in acute aural catarrh, but if there is inflammation of any part of the external ear, ordinary examination with the speculum, which necessitates some traction on the auricle and meatus, will cause pain. This is often a partial means of finding out, in a case of asserted pain in the ear, where the seat of the disease is, or at least what division of the ear is probably most affected.

Prognosis.—The prognosis of acute catarrh of the middle ear is, on the whole, favorable. By careful observance of all the symptoms and prompt application of the treatment about to be detailed, usually the disease will terminate favorably. It should never be neglected, even in its mildest forms, since repeated slight attacks are very likely to lead at last to permanent hardness of hearing.

Treatment.—The milder forms of congestion are to be treated by relieving the general catarrhal symptoms, and a thorough inflation of the tympanum. The *first* object is to be gained by opening the bowels, if necessary, and restoring the function of the skin, which is usually more or less disturbed. A mild diet must be observed, and spirituous drinks, smoking, chewing, and suffing tobacco are to be sedulously avoided. The patient must be housed, and a sudorific and anodyne regimen observed. The *second* object, inflating the tympanic cavity, is to be gained by using Politzer's air-bag, the Eustachian catheter, or Valsalva's method of inflation. The latter mode of inflation consists in the patient's holding his nose and forcing air, by powerful expiration, into the tympanum while his mouth is closed. By thus inflating the tympanum, the formation of a vacuum is prevented and the secretions are forced away from the ossicles and allowed to escape through the artificially opened Eustachian tube, or they become rapidly absorbed.

Air blown by the air-bag into the nostrils of children, will force open the Eustachian tube without any coöperation on the part of the patients; in fact, crying on their part will *lift up* the palate, shut off the lower from the upper pharynx, and facilitate the passage of air into the tympanum.

If the child is tractable, puffing out the cheeks with closed lips, according to the suggestion of E. E. Holt, prolonged phonation of the vowel a, or of the words hick, hack, hock, etc., according to the suggestions of Lucæ[1] and Gruber,[2] will aid in lifting the soft palate and in closing the nasopharynx from the cavity of the mouth and throat. At the moment of, or during the distention of the cheeks, or of the prolonged phonation, air may be forced into the tympana by Politzer's bag; if only one tympanum needs inflation, the one opposite to it may be firmly stopped with the finger during the operation of inflation, and thus, in some cases, it seems that more air is forced into the ear to be ventilated, because of the greater resistance offered, by the voluntarily stopped ear, to the column of air pressed into the nasopharynx.

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[1] Virchow's Archiv, vol. xliv.

[2] Monatsschr. f. O., Nos. 10 and 11, 1875.

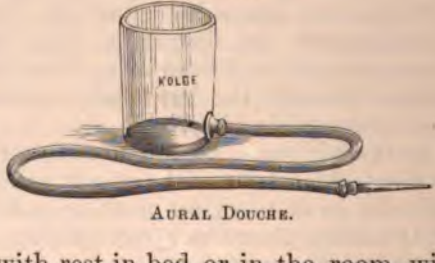
The treatment need not be actively antiphlogistic unless the pain and fever become severe. Should the pain grow intense, leeches must be applied in front of the tragus, as near as possible to the ear, directly in front of the tragus or under the auricle. This tends to prevent suppuration.

Before leeches are applied, the mouth of the auditory canal should be stopped with cotton to prevent their crawling into the meatus. Such a mishap would cause the patient not only intense pain but most probably a severe external otitis. Hence, the advice sometimes given to deliberately apply the leech to the meatus is to be rejected. Even in the most favorable spot, a leech-bite not unfrequently produces a circumscribed abscess.

Anodynes.—Anodynes should be given in doses sufficient to allay pain and produce sleep at night. Aconite, in doses proportioned to age, is of great value in acute otitis. A hop pillow, or any form of dry heat, will often prove very grateful in this malady.

In addition to the above means, warm and soothing gargles, and warm applications with the syringe or aural douche, to the ear, together with rest in bed or in the room, will be found to hasten restoration to health and hearing.

Fig. 87.



AURAL DOUCHE.

Spraying the Nasopharynx.—In cases of acute aural catarrh, in which the fauces, nasopharynx, and Eustachian tube are especially inflamed, spraying of these parts by warm fluids will be found grateful to the patient and very useful in the treatment of the disease.

Warm water, slightly impregnated with salt (fifty-six grains to the pint) is often employed, and in acute cases is of some value. But warm water containing chlorate of potash (3–5 gr. to f℥j), four or five-grain solutions of borax or of boracic acid, or bicarbonate of soda, four or five grains to the fluidounce of water, will prove more useful in all cases than solutions of salt.

The most convenient form of application of warm spray to the nasopharynx is by means of a hand atomizer; the steam atomizer may be used, but it is not nearly as convenient as the hand-apparatus.

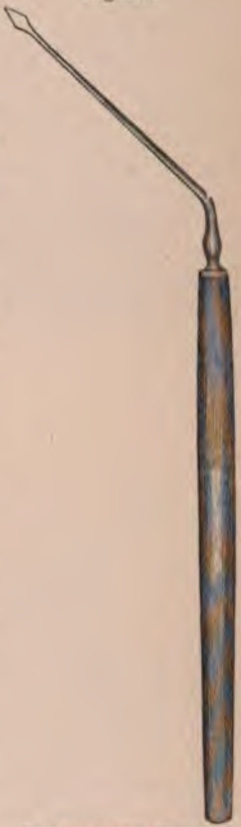
It can but be repeated here that all forms of oils and fats are to be kept most carefully out of the ear, in this as in all other acute aural diseases. Sweet oil and other fats not only clog the ear and mask the disease, but they load the drum-membrane, increase the pain, and, as they are usually forgotten and left in the ear after the pain ceases, they become rancid and favor the growth of fungi. These, in turn, produce a painful and troublesome acute disease of the external, and even of the middle ear (p. 263).

It would be well if it were remembered that most of the so-called remedies for earache would make a well ear painful if they were put into it.

Paracentesis of the Membrana Tympani.—If the collection of mucus in the tympanum becomes great, the membrane bulge, and the pain continue, it will generally be best to incise the membrana tympani.

This should be done by means of the specially devised knife shown in Fig. 88, at the posterior inferior quadrant, unless some other point protrudes very greatly. This operation is to be performed under perfect illumination and inspection of the auditory canal and membrana tympani, by means of the forehead-mirror and a speculum. The latter should be as wide as can be admitted comfortably into the meatus. The incision may be in the form of a stab or slit. Usually some of the retained mucus, or muco-pus, will issue from the wound instantly. It may be further aided in its escape from the tympanic cavity by

Fig. 88.



PARACENTESIS KNIFE.

some form of inflation, preferably by Valsalva's method. But the latter aid, which is quite sufficient, should be gently effected. The syringe need not be employed at all to remove mucus or any matter from the tympanic cavity immediately after paracentesis of the drum-membrane. It often is not even necessary to resort to inflation at first, since the elastic force in the retained matter is quite sufficient to favor its escape after the incision in the membrana tympani. This operation is simple enough, but a very important one. It leaves none but good results behind it when properly done, but it is not to be undertaken without careful consideration, and never simply for the relief of pain. Its chief indication is to permit the escape from the drum-cavity of retained products of inflammation, accompanied by pain and deafness. Unless the surgeon can recognize the presence of matter in the drum-cavity, and is convinced that such retention is provocative of continued pain or deafness, and is also threatening to produce a large destruction of tissue in the drum-membrane, by an ultimate perforative ulceration, he cannot be justified in resorting to the operation of paracentesis of the membrane in any form of acute otitis media.

CHAPTER II.

CHRONIC CATARRHAL INFLAMMATION.

The onset of this disease is usually insidious. It may be preceded by numerous painful attacks of acute aural catarrh, but very frequently there is no history of precedent acute catarrh of the ear. Chronic catarrh of the middle ear is seen under two chief forms: (*a*) the secretory or moist, and (*b*) the asecretory or dry form. To these aspects of the chronic disease, different names, and in some cases vastly different natures have been assigned. But in both of these chief forms it is usually found, on close examination, that a markedly catarrhal condition of adjacent and related mucous tissues, either has preceded or attends the chronic aural disease. Even in those cases of chronic aural disease in which the nervous features are prominent, the latter usually are seen to be due to nutrient disturbances in the nerves of the middle ear, and possibly of the internal ear, induced by the antecedent aural catarrh. Inded, it seems that many cases of aural vertigo, under its numerous names, might be traced back to a chronic catarrhal disease of the middle ear.

Chronic aural catarrh, therefore, with its multitude of symptoms, has given rise to many different opinions as to its real nature and also to a very diverse nomenclature. This is due to the fact that the observation of the disease has usually begun at a more or less advanced stage of the affection, and but rarely continued until terminated by a careful study of the diseased tissues after death. Hence the number of names applied to this malady, as, "nervous deafness," "hypertrophic" and "proliferous inflammation," "sclerosis," and "chronic thickening of the mucous membrane of the tympanum," "anchylosis of the stapes," and "progressive hardness of hearing." They all possess the merit of designating at least marked characteristics of the malady to which they are applied. To the inquiring and observant student of aural disease, each of these terms will offer itself in many cases as the best descriptive name of the tedious complaint he finds before him. But no single one of them admits of universal application. "Chronic catarrh" seems to me to be indeed the only universally applicable name. It is comprehensive, and surely serves to denominate the essential nature of the disease.

SUBJECTIVE SYMPTOMS.

The earliest subjective symptoms of this disease are tinnitus aurium and a gradual diminution of the hearing. These symptoms appear usually only in one ear at a time, most commonly the left, and a varying period may elapse before the other ear is attacked. The onset of the subjective noise in the ear may be quite sudden; the time of its first occurrence can usually be stated accurately by the patient. This subjective buzzing, chirping, or hissing may appear on rising in the morning, during or after a severe cold in the head or after a depressing illness. The noise is not intense at first, but gradually becomes louder and more annoying, the hearing usually diminishing at the same rate. The statements of patients as to the quality and character of the subjective aural noise are extremely varying. The objective sounds to which they are likened are commonly taken from the sounds to which the patient is most exposed; the mechanic seems to hear noises of machinery, the student the hissing or buzzing of a lamp, while the simmering of the teakettle is a universal similitude used to explain the quality of tinnitus aurium. In many cases a hyperæsthesia to objective sound seems to come on with the annoying subjective noises. I have known patients suffering with distressing subjective hissing in the ear and greatly reduced hearing, to complain bitterly of the intensely disagreeable effect on the diseased ear of the noises of the street, and even of the blowing of the wind across the auricle while walking. This sensitiveness may persist for months. Sometimes patients seem to get used to the noise in the ear. When their attention is specially drawn to it they will sometimes state that they are aware of a singing in the ear but it is of no great moment to them. The singing in the ears is not very severe, nor does it grow louder in these cases. All subjective noises of the ear in this disease may be increased by fatigue, drinking spirits, smoking, and prolonged conversation. In some cases, after each meal the noise seems much louder. Some authorities[1] state that abnormal conditions of the genito-urinary apparatus tend to aggravate the tinnitus of chronic aural catarrh. It is very certain that gastric and intestinal derangements tend to make tinnitus aurium more intense.

But in some cases, tinnitus aurium either never appears in the disease or only at a later stage, long after the hearing is much reduced.

These cases, being deprived of the warning as to the threatened failure of the function of the ear found in tinnitus aurium, are rarely made aware of the loss in hearing until it becomes very great. This is especially the case when one ear remains perfect. A failure of hearing in it, temporary or otherwise, is often the first occasion for noticing the defect in the other ear.

A patient may come with the statement that while lying on the good ear in bed, accidentally it was discovered that some ordinary sound, such as the voice of a friend, the crying of a child, or the bell on the street-car, was not perceived by the free ear.

This has led to domestic testing with a watch or a clock, and these are found to be not perceived, or but imperfectly, in the ear which now for the first time is discovered to be faulty.

The coming on of this kind of deafness is so insidious that, in many cases, even among the most intelligent, there is no reliable history of the origin of the disease. I have known children of physicians to be thus affected, but their fathers were not able to state when and how the disease probably began.

These cases, with no definite account of the beginning of deafness, seem, in my experience, to belong to a class with hereditary tendencies to chronic catarrh of the ear.

In the case of a physician's child, I found the father affected in one ear; in a young lawyer's, the father and uncles were similarly troubled. A young gentleman, growing markedly deaf in both ears, lately aggravated, as he thought, by shooting, stated that his family in some branches grew deaf, but he could not tell when the disease began to appear in him; he thought perhaps after undue exposure in the army ten years before. And such cases might be cited by scores.

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[1] Weber-Liel, Progressive Schwerhörigkeit, p. 19.

Darts of pain are felt in some cases, every day or two; but this is not a very frequent symptom. If it occur, it is only in the earlier stages. Most patients complain of a sense of fulness and discomfort in the ear, as the disease advances. If the secretion of mucus is considerable, more or less cracking is heard in the ear by the patient. After the ear cracks, it seems open for a little while, and the patient may hear better. But in a short time the sense of stoppage in the ear returns, and the hardness of hearing is again present.

But the pain and the sense of fulness are increased by changes in the weather during the winter season. In summer all such symptoms are very much less prominent. A great sensitiveness of the ear may coexist with great deafness. Sounds which cannot be fully understood, *i. e.*, words which are perceived only as sound, uttered very near an ear rendered entirely deaf by catarrh, will often produce pain in the ear.

With the tinnitus aurium, loss of hearing, and darting pain in some cases, disagreeable sensations are felt in the fauces, throat, and larynx. The character of these subjective conditions is variously described by the sufferers.

Most of them complain, however, of constriction, tickling, sensation of fulness, and burning in the throat. All of these are aggravated by cold, any depressed state of health, or often by stimulating food, and by dyspepsia with constipation. In some instances after an ordinary hearty meal, the throat will feel more or less burning, which is aggravated if the patient is obliged to talk in any prolonged way.

Very often the disagreeable feeling in the throat is described as that of a hair or foreign substance lying in the fauces, but which still clings there notwithstanding all efforts at swallowing. According to Weber-Liel,[1] this symptom is specially apt to be complained of by females. In a state of health all acts of swallowing can be felt, or heard, in the Eustachian tube and middle ear. But in these cases of chronic aural disease attended with pharyngeal symptoms, swallowing cannot be perceived in the affected ear by the patient; not even when the attention is drawn to the normal process by the physician.

Very few persons are aware that at each act of swallowing, they can perceive, if the Eustachian tube is in a normal state, a sensation of opening and crackling in the ear. This peculiar thud felt in the ears, at swallowing, is but the normal process of ventilation of the tympanic cavity. When the attention of one possessing good ears is drawn to this fact, it is then recognized, usually for the first time, so accustomed do all become to normal physiological processes. Consequently any symptomatic change in this respect must be inquired for by the physician; for the patients never volunteer any information on this point, being, as already stated, ignorant of what a normal ear might perceive in swallowing.

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[1] Op. cit., p. 23.

Vertigo is sometimes felt in the later stages of this disease, but it cannot be considered a very common symptom, according to my experience. When it is present as a symptom of chronic aural catarrh, it is paroxysmal in character. This characteristic alone would help to diagnosticate it from vertigo caused by cerebral disease. In the latter instance, the vertigo, if it occurs, is either constant or invariably produced by some particular act, like walking, and there is more or less permanent alteration in the gait. Vertigo caused by chronic aural disease is usually connected with an increase in the subjective noises and an aggravation of the deafness. In such cases, any force which increases the pressure in the tympanic cavity is apt to bring on an attack of giddiness, as, for example, sudden swallowing, prolonged acts of deglutition, and powerful inflations of the tympanic cavity, either by natural or artificial means. Changes in the weather, and consequent increases in the catarrhal symptoms, will often lend their aid in producing a greater tendency to aural vertigo. In most cases, by abatement of the catarrhal congestion, the vertigo will be lessened. In all such cases the Eustachian tube will be found to be at least temporarily narrowed, and the tympanum consequently imperfectly ventilated. The vertigo produced by inflation of a middle ear already diseased by chronic catarrh, and in which the membrana tympani is indrawn and more or less unyielding to forces intended to push it outward, is due to pressure on the foot-plate of the stirrup-bone and upon the membrane of the round window. The latter membrane is highly susceptible to changes of atmospheric pressure in the tympanum, as recently shown by Weber-Liel.[1]

Since, in the catarrhal ear, the drum-head is both stiffened and held inward by the retraction of the tensor tympani muscle, air forced into the drum-cavity, instead of equalizing the pressure by carrying ahead of it the membrana tympani, which forms so large a part of the outer wall of the drum-cavity, is suddenly spent upon the more delicate coverings of the fenestræ in the inner wall of the tympanum. Pressure thus exerted on the labyrinth-fluid must produce not only a morbid oscillation and compression of the terminal filaments of the nerve of hearing, but also an alteration in the pressure of the cerebro-spinal fluid, for the labyrinthine fluid has been shown[1] to be in direct communication with the cerebro-spinal fluid.

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[1] Centralblatt für die Med. Wissenschaften, No. 2, 1876.

The auditory nerve has motor as well as sensory fibres. A portion of the fibres of origin of the auditory nerve are closely connected with a mass of motor cells in the bulb.[2] These fibres pass into, and are continued in, the inferior peduncles of the cerebellum. Further, it is known that the motor filaments of the auditory nerve are distributed to the ampullæ of the semicircular canals, the sensory fibres passing to other parts of the labyrinth. By excitation of the ampullar nerves, reflex motor excitation is conveyed to the cerebellum, the phenomena of which will be considered more fully under aural vertigo.

Therefore it can be seen how undue pressure in the labyrinth can be conveyed to the brain, and produce cerebro-aural symptoms.

Hearing Better in a Noise.—Hearing better in a noise is very often a marked symptom of the later stages of chronic aural catarrrh, when the condition of the tympanum has become dry and sclerotic, or when the thickening of the mucous membrane has become great in the moist form of the disease. This condition of the hearing, once supposed to be a mere fancy on the part of the patients, or at least due to the general elevation of the voice all are obliged to assume in a noise, has been shown to be real. Those presenting this symptom, Paracusis Willisiana, are found upon examination to hear the ticking of a watch somewhat better in a noise, for instance, in a mill or a railway train, than in a quieter place. No entirely satisfactory explanation has ever yet been given for this.

Dr. A. H. Buck mentions,[3] but does not claim as an original idea, the following explanation for this peculiarity in hearing. "The pathological condition in the cases here under consideration is assumed to be one of rigidity, either of the annular membrane or ligament which holds the foot-plate of the stirrup in the fenestra ovalis, or of the secondary tympanic membrane covering the fenestra rotunda. Ordinary waves of sound, such, for instance, as are produced in ordinary conversation, are not of sufficient strength to overcome the rigidity of the annular ligament or of the secondary tympanic membrane; consequently the patient fails to hear the conversation. In the midst of loud noise, however, waves of sound are produced of sufficient strength to set the stirrup in motion in spite of the existing pathological obstacles. Once in vibration, this little ossicle, which might very properly be called the key to the auditory chamber, can perform with a certain degree of freedom the subordinate vibrations called into existence by the conversation which is being carried on near by, vibrations which are necessary to the act of hearing it. The louder tones open the door for the entrance of the feebler ones." This can be most safely considered a sign of great rigidity in the sound-conducting parts of the tympanic cavity, and also a very unfavorable omen.

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[1] Weber-Liel, Monatsschr. f. Ohrenh., Berlin, August, 1870, and Prof. Hasse, Anat. Studien, No. xix. p. 768.

[2] Duval: See Gellé, De l'Oreille, p. 323, Paris, 1881.

[3] Report on the Progress of Otology, N. Y. Record, June 5, 1875.

Hereditary Tendency.—The tendency to this disease is markedly hereditary. Recently I have been consulted by a woman and her seven children for chronic aural catarrh. The woman was about 40 years old; the oldest child was about 18 years old. The disease manifested itself early in life in the children, the worst of whom was a boy about 11 years old. The family were in the hard-working class, and but moderately nourished. The boy, the worst case, was at school.

Odor.—A symptom of this disease is a peculiar odor which I have noted, pervading the vast majority of those in the mature stages of chronic aural catarrh. It is not at all like the odor of ozœna; it is more like that of saliva. By simply passing one's tongue over one's finger, and allowing the saliva to evaporate slowly, this odor may be simulated. It cannot be called offensive, and it is not perceived at any distance from the patient. It seems to emanate through the nose, and is more noticeable in females than in males, because in the latter it is usually disguised by tobacco. This odor, I think, is due to a disordered condition of the follicles of the mucous membrane of the fauces, mouth, nasopharynx, and nose.

OBJECTIVE SYMPTOMS.

Appearances in the External Auditory Canal.—It may be said that in chronic aural catarrh characteristic changes occur in the external auditory canal. Chief among these is the diminished or suspended secretion of cerumen. The ear-wax not only becomes smaller in amount, but often assumes a brittle quality; later it often ceases to be formed at all. This points to a great alteration in the nutrition ot the organ of hearing. This important excretion ceasing to be poured into the auditory canal, there set in a dryness and scaly condition of the skin of the meatus. This latter state favors the growth of aspergillus.

Membrana Tympani; Changes in Color.—The membrana tympani usually loses its lustre and transparency in chronic aural catarrh. But as these changes are not always indicative of such a disease in the tympanum, they must never be regarded as of positive value. In some cases of chronic catarrh of the middle ear, the membrana tympani may be thinner than usual, and cases are met with in which the lustre remains unchanged. In the latter instance, the chronic alterations in the mucous membrane of the middle ear have most probably occurred elsewhere than on the inner surface of the drum-head. The membrana tympani may appear uniformly pink from the transmission of the redness of the congested mucous membrane on the promontory.

Another important fact to bear in mind respecting color-changes in the drum-head is that, even in those with normal hearing, especially in children, the membrana tympani is not unfrequently rather dull in appearance for longer or shorter periods. The lustre of the membrane is most easily lost; alterations in tenuity are more indicative of a deeper change in structure.

Calcareous Deposits.—Chalky spots may be found in the drum-head of an ear affected by chronic catarrh; but they cannot be considered characteristic of the disease. They are usually traceable to a previous purulent disease in the ear, all other traces of which have gone, for it is not uncommon to find these deposits entirely unaccompanied by hardness of hearing. Calcareous spots may arise in the course of a chronic aural catarrh.

After an experience of fourteen years, in the daily examination of the drum-head, both in Europe and America, I am struck by the general rarity of chalky spots in the membrana tympani of those born in the latter country. It seems that these deposits are much more frequent in those born and reared in Northern Europe. Perhaps the milder climate of the latitude of this city may account for their rarity in the drum-heads of those born here.

Changes in Position of the Membrana Tympani—A much surer objective symptom of chronic aural catarrh, especially when joined to opacity and loss of lustre, is a retraction of the membrana tympani. The drum-head then appears drawn in, and the manubrium of the malleus foreshortened, the short process of the latter projects more sharply than usual, and the folds of the membrana tympani (see p. 52) are very prominent. The manubrium is not only indrawn, but is pulled backwards and upwards, and the entire concavity and curves of the drum-head being thus altered, the pyramid of light, normally found in the antero-inferior quadrant, is very much changed in position, or it may disappear altogether (see p. 53). As the latter reflection depends on the lustre as well as the curve and position of the drum-head, and as more or less opacity is found in chronic aural catarrh, the normal pyramid of light is usually one of the first features to vanish from the diseased membrane. The manubrium not only appears indrawn, but rotated about its long vertical axis so as to pull the posterior half of the drum-head into greater prominence, and to drag the anterior half into a greater depression. The causes of this retraction of the membrana tympani and malleus have been variously assigned by several distinguished observers. Politzer is of the opinion that the swollen and chronically diseased condition of the Eustachian tube interferes so much with the normal ventilation of the tympanic cavity as to cause a constant want of air, if not an entire vacuum, in it. This want causes a disturbance in equilibrium in the atmospheric pressure on each side of the drum-head, and the preponderance of the external air forces the drum-head in and relaxes the tendon of the tensor tympani muscle. This in turn may, by fatty degeneration or adhesion, or both, or by contraction from want of use, fix the drum-head in its indrawn position. In such a condition, the want of air in the tympanic cavity is the prime factor in the retraction of the drum-head.

Weber-Liel ascribes the drawing in of the membrana tympani chiefly to the retraction of the tensor tympani muscle. This muscle is described by him as a part of the palatal and tubal muscles (see p. 109). The latter, becoming diseased and undergoing fatty degeneration, are no longer able to preserve their proper amount of tension, and hence occur disturbances in the equilibrium of the muscular structures of the middle ear. In this process (defective motility of the faucio-tubal muscle), the paralysis of the tensor veli sive dilator tubæ plays very probably the chief part, not only because of the resultant persistent and ever-increasing hinderance to the ventilation of the tympanic cavity, but also because this muscle, which stands in the relation of antagonist to the *tensor tympani*, when paralyzed, is the chief causative power of the *antagonistic contraction* of the tensor tympani.[1]

Implication of the Sympathetic and other Nerves; Flushing of the Cutaneous Surface adjacent to the Ear.—Among the objective symptoms of chronic aural catarrh may be mentioned implications, more or less frequent, of the sympathetic nerve. It is not uncommon to find "complex disturbances in the correlated tracts of the vagus, glosso-pharyngeus, facial, auricularis magnus, and the accessorius nerves, standing in close connection with aural maladies of this nature. It is also not at all uncommon to find in deaf women, suffering from spinal irritation, muscular weakness, and rheumatic pains in the muscles of the throat and neck, sensitive spots on the side of the neck, behind the sterno-cleido-mastoid muscle, where the auricularis magnus and accessorius arise. Pressure on these spots causes not only pain running down to the shoulder, but also occasions, in the ear on the corresponding side, a feeling of fulness and more or less tinnitus aurium."[1]

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[1] Weber-Liel, op. cit., p. 14.

In some cases of chronic aural catarrh, especially in the dry form, called by some writers progressive hardness of hearing, a flushing of the skin near the ear is observed. I have seen but three cases in which distinct, deep-tinted, and circumscribed flushing of the surface of the skin near the ear, was connected with tinnitus aurium and progressive hardness of hearing.[2] The history in these cases was such as to lead to the conclusion that this peculiar vascular congestion in the skin may be, in some instances, a symptom of aural disease. Weber-Liel[3] has described a case which presented, in one ear, symptoms resembling those observed by Bernard, after section of the cervical sympathetic.

In some cases it must be admitted that the distinctly catarrhal symptoms are much less prominent than the nervous features of the disease, and such cases have given rise to the theory of nervous deafness. But my conviction is that upon ordinary search all such cases, no matter how prominent the nervous symptoms may be, when the case presents itself for treatment, can be traced back to a causative catarrhal trouble in the fauces, Eustachian tube, and middle ear. But it must be admitted that there are many good reasons for assigning to some cases a nervous nature, as may be seen by the following cases:

CASE I. I was asked by Dr. T. Hollingsworth Andrews, in May, 1874, to see with him a young lady, 26 years old, unmarried, of large, robust frame, a resident of the western part of Pennsylvania. Six years previous to the time I saw her, she had suffered from an attack of probably rheumatic facial paralysis on the right side. Within two or three years she had noticed a diminution in hearing, accompanied by an uninterrupted and distressing singing in her ears. The hearing on the right side was reduced to $\frac{3}{60}$; on the left, to $\frac{6}{60}$ for the watch. The tuning-fork, placed on the vertex, was heard better in the *better* ear. The membrana tympani on the right side was more retracted than on the left. The lustre of both was good. The Eustachian tubes were pervious.

There was, in this case, a constant quivering of the buccal and labial muscles, which dated back for a year or more. *There was also a distinct purplish-red flush over the cheeks and neck as far as the clavicle, with an increase in the tinnitus whenever the patient was*

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[1] Weber-Liel, op. cit., p. 3.

[2] Three cases of tinnitus aurium and deafness, accompanied by very distinct flushing of the cutaneous surface adjacent to the ear, by the author, in Archives of Oph. and Otol., vol. iv.

[3] Op. cit., p. 2.

even ordinarily excited or fatigued. The application of the constant electric current from a Brenner apparatus, at the time of the examination, did not afford even temporary relief to the tinnitus. I saw the case but once.

CASE II. Mrs. Van C., 56 years old, patient in the Presbyterian Hospital, in Philadelphia; a farmer's wife, small and thin. She stated that at the menopausis she experienced a sudden and excessive tinnitus aurium, which, however, had diminished in severity since then, but, though it had become quite endurable, it had never entirely ceased even temporarily. The hearing did not appear to be affected in this case. There was, however, a peculiar vascular congestion or flushing, deep carmine in color, which came on with any considerable fatigue or excitement, and was attended with an increase in the tinnitus aurium.

This flush extended from both ears, where it seemed to start, over each sterno-cleido-mastoid muscle, forwards toward the thyroid gland, where the blushes of each side coalesced and extended over the chest and mammæ. At the same time, a similarly tinted blush extended over the nucha and upper part of the back and shoulders, so that the woman appeared covered by a carmine-colored cape with the limits already designated. The rest of the skin-surface was sallow. There were, at this time, some linear blushes running from the ears forwards over the temples, uniting across the forehead. This truly objective flushing was probably analogous to the subjective flushes so often felt by women at the menopausis.

CASE III. Mrs. McA., of Delaware, a very large, strong woman, aged 45 years, living in a malarial district, and then in her eleventh pregnancy. The patient stated that she had had an increasing hardness of hearing, with tinnitus on both sides, for some years. The drum-heads were opaque. In her case there was a *peculiar flush* on the left cheek, corresponding to the worse ear, which became apparent on exertion or exposure to heat or cold, and was coincident with an increase of tinnitus aurium. This case grew much better while taking $\frac{1}{45}$ gr. of strychnia thrice daily and using the constant electric current.

The history of these cases adds something to the knowledge of a form of aural disease in which the nervous symptoms predominate.

Since similar flushing has occurred from well-known *direct* lesion of the sympathetic, it is fair to assume that the flushing in the cases I have just narrated must also have been due to an irritation of the sympathetic. In two of the cases, as there were other symptoms of chronic alterations in the organ of hearing, it would seem probable that in them, at least, the flushings were directly traceable to the aural malady. In the second case, it may have been but the precursor of deafness.

Circumscribed flushing of the cutaneous surface in any part of the body, whether from external violence or internal causes, is rare and in many respects unsolved.

In a case[1] of direct mechanical violence to the sympathetic nerve, the only known case at that time on record, "the face presented, after walking in the heat, a distinct flush on the right side, and was pale on the left. The right half of the face was very red. The flush extended to the middle line, but was less definite as to its limit on the chin and lips than above these points."

Dr. Wm. Ogle[2] has reported a case of probable destruction of the right cervical sympathetic by abscesses. In this case "the eyeball was retracted, the palpebral fissure narrowed, the pupil contracted, the right side of the face redder and hotter than the left during repose, but after violent exercise or fever, colder. The left side of the face alone sweated, and the right side of the mouth and tongue was complained of as being dry."

In a case[3] under the care of M. Trélat, at the St. Louis, in Paris, in which the sympathetic nerve had been destroyed by an operation for removal of a deep-seated tumor of the neck, "on the day following the operation, the face was deeply congested, especially on the right side, which displayed well-defined patches of violet and red color."

These cases are cited because they present instances of flushing of the face and parts of the head from known and direct lesions of the sympathetic nerve. In the three cases I observed and have related above, there was well-defined flushing without history of external violence to the sympathetic nerve. Therefore it seems fair to conclude that the nerve was affected from within, and to it treatment would be well directed.

Nares.—The changes in the nares, often attending, and apparently in many cases promotive of, chronic aural catarrh, may be very great. There is what in brief may be termed hypertrophic catarrh of the nares in these cases. The hypertrophy is usually found on the inferior turbinated bones, though it may invade all the membranous structures of the nostrils, either on the turbinated bones or upon the septum. Posterior nasal hypertrophies are the most important, on account of their proximity to the faucial end of the Eustachian tube. There are often found enchondromatous enlargements on the septum, deviations of the septum, and other forms of obstruction in the nares in the subjects of chronic aural catarrh. These obstructions, as may be supposed, interfere with normal nasal respiration, and lead to mouth-breathing. Thus the throat becomes affected by the irritation of direct respiration, and the nares and nasopharynx become further affected by being deprived of the normal stimulus of nasal respiration. The Eustachian tube, deprived of the natural stimulus of nasal respiration fails to become patulous as often as it should, and may remain closed for long periods, and the drum-cavity is thus deprived of its normal quantity of ventilation. This condition, in turn, fixes the ossicles, retracts the membrana tympani, and tends to the production of anchylosis in the sound-conducting apparatus of the middle ear.

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[1] "Gunshot and Other Injuries of the Nerves." Mitchell, Morehouse and Keen. Philadelphia, 1874.

[2] Medico-Chirurgical Transactions, vol. lii. p. 154.

[3] See Abstract in Med. Press and Circular, p. 78, Jan. 1869

The Condition of the Pharynx and Throat.—The pharynx, tonsils, and velum will be found to present varying appearances according to the form of the disease.

In the moist form the secretion of mucus will be markedly increased, and the glandular structures of the mucous lining of the fauces will appear enlarged and inflamed, their function being of course stimulated by the disease.

The tonsils are usually very much enlarged in this form of the disease, and the velum appears swollen. But this is only an accompaniment of the general catarrh, not the cause of it in the ear nor of the hardness of hearing. It will very often be found that the most swollen tonsil is on the side of the better ear. The secretion of the nose is also very apt to be abnormally great. This form of the disease really deserves the name of catarrh in its strict meaning of "flowing" or "running."

But many cases of chronic aural catarrh do not continue to show this abnormal amount of secretion in the pharynx. In these cases the mucous membrane has either rapidly ceased to throw off large amounts of mucus, or it has slipped at once into an atonic and dry state. In such cases the mucous membrane of the entire pharynx, especially on the posterior wall, is pale and, at spots, apparently cicatrized. It may even somewhat resemble granular pharyngitis without marked secretion.

The *velum* appears rather thinner than natural, as though its muscular structures were atrophied, as indeed they are; and the *raphe* is no longer directly in the median line, nor are the halves symmetrical in shape and position. A paresis has apparently affected one half more than the other, and the uvula and the weaker half will be drawn toward the stronger side, which will usually be found to agree with the better ear. All of these changes in the action of the muscles of the fauces must be attributed to the effects of the catarrh.

Loss of Function in the Velum.—The loss of normal mobility in the velum is further seen when the patient is told to phonate the vowel *a* broad. Then, the velum and uvula, instead of rising quickly to shut off the lower from the upper pharynx, will fail more or less to fulfil this function. The uvula either hangs loose and downward, quite relaxed, or it clings to one or the other side, on the edge of the velum. As the patient phonates, the uvula may slip from this position on the velum and hang loosely downward, or it may curve forward or backward against the posterior wall of the pharynx. In such conditions, sudden eructation, coughing, or sneezing may at times produce pain in the ear. It is also very noticeable that the act of swallowing cannot be performed rapidly by persons thus affected in the faucial muscles.

Changes in the Voice.—With these alterations in the ear and throat, the vocal functions usually become weaker. The timbre of the voice is altered, and, if the patient has been a singer, the voice is found to be rapidly losing musical power. A kind of hoarseness sets in, when singing or prolonged conversation is attempted. The voice "breaks" or "cracks," and a general sense of fatigue in the throat becomes a prominent and distressing symptom. My observation leads me to conclude that all of these alterations in the throat usually begin to appear before the early morbid changes in the ear. The latter seems to become affected by a passing inward and upward of the nasal and throat-disease, through the tube into the tympanic cavity. When once there, a long series of nutrient changes begin, which, with varying symptoms, usually terminate in total deafness; though in some cases chronic aural catarrh seems to stand still after having diminished, but not destroyed, the function of the ear.

A marked characteristic of chronic aural catarrh is not only to advance slowly and surely in one ear, but to pass to the other, sooner or later. The changing of the voice, *i. e.*, the gradual assumption by the patient of a high and peculiar pitch in the voice in talking, will often aid in diagnosticating a chronic catarrhal affection of the middle ear, even when the patient is sure that the aural malady is of sudden advent.

"An explanation of the numerous symptoms of affections of the vocal organs, so often associated with aural disease, may be sought in the direct connection between the acoustic nucleus (by means of the acoustic trunk) and the probable centre of speech in the cortex of the island of Riel. On the other hand, it is important to bear in mind the anastomosis between the vagus and the petrosal ganglion of the glosso-pharyngeal nerve (tympanic plexus, tubal nerves) and the auricular branch of the pneumogastric nerve, which, in this instance, plays the part of a communicating link. During the insertion of a probe into the Eustachian tube of one possessed of good ears, pain is felt in the larynx when the probe reaches the isthmus. This is felt before the person operated on is aware of the presence of the probe in the ear. In perichondritis crico-arytenoidea there is always pain in the ear."[1]

Saissy relates that in the records of the Parisian Academy of Sciences for the year 1705, a singular case is accredited: "A young man, 20 years old, lost both hearing and speech after his larynx had been squeezed by a strong man, in a fight. All means tried for the restoration of hearing failed in this case."[2]

Objective Changes in the Eustachian Tube.—As may be inferred, from what has been already said in the preceding pages, the Eustachian tube, being lined with mucous membrane continuous with that of the fauces and of the tympanic cavity, and forming such an important part of the middle ear, undergoes serious and most important changes in chronic aural catarrh. These changes are due primarily to thickening of the lining of the tube, or to obstruction of its calibre by mucus. Hence arise very striking objective symptoms, which become apparent to the surgeon upon using the Valsalvan method of inflation, the Eustachian catheter, Politzer's inflation-bag, or bougies for dilatation of the tube. To all of the processes of inflating the drum, and to the probe, the tube will offer more or less resistance; in some rare instances the inflammatory process may have been so great as to cause an entire closure of the tube at the isthmus.

Upon auscultation of a catarrhal ear, into which some air enters from the catheter, the sound perceived by the auscultator will reveal the presence of mucus in the Eustachian tube, or a narrowing of the same with perhaps a diminution of secretion. The first condition is found in the moist form; the latter sound, that of air rushing through a narrow and dry tube, is of course found in those cases in which the secretion is not in large amount, and in which the catarrh has led to a hypertrophic process throughout the mucous and submucous tract of the tube.

These symptoms of obstruction, usually ascribed to the changes just named, are accounted for somewhat differently by Weber-Liel. This observer states that in many cases of asecretory catarrh of the middle ear, or, as he calls it, progressive hardness of hearing, the Eustachian tube is easily permeable to a bougie, but not to air by any ordinary means of inflation. The cause assigned for this obstruction to the entrance of air, is the relaxed condition of the muscular walls of the tube. So great is this relaxation, that the flaccid walls cannot be forced apart by any of the ordinary means of inflation.

Be this as it may, the cause of this muscular weakness, atrophy, or paresis, is, in my opinion, to be considered *secondary* to the catarrhal inflammation. This is analogous to processes in other muscular structures underlying mucous membrane elsewhere in the body. Thus in the alimentary tract, muscular derangements are constantly found following close upon catarrhal disease of its mucous lining; the same may be said of the bladder and of the lung. In all of these, a prominent symptomatic change, following close upon inflammation of their mucous layer, is the want of proper contractility in the subjacent muscular structures. It would, therefore, seem much simpler to account for the symptoms of muscular derangement in the middle ear, affected by chronic catarrh, in the same way as muscular alterations occurring in a chronically inflamed bronchus are explained.

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[1] Weber-Liel, op. cit., p. 35.

[2] Quoted by Weber-Liel, loc. cit.

The mucous membrane of the nose, pharynx, and Eustachian tube may be not only greatly congested and swollen, but extremely irritable, assuming almost an erectile nature. In such cases, merely smelling an irritating substance has been known to produce an instantaneous closure of the Eustachian tube, altered pressure in the tympanic cavity, deafness, and sudden unconsciousness.

Erhard[1] mentions the case of a boy, whose nasal and Eustachian mucous membrane possessed such peculiar irritability that upon applying his nose for an instant to a bottle containing sulphuric ether, all of the above symptoms ensued, not only once, but repeatedly for many days in succession, whenever Erhard desired to demonstrate the case to his pupils. Upon inflating the tympana in this case, consciousness instantly returned. This case points unmistakably to a sudden closing of the tubes, a disturbed equilibrium in the membrana tympani, forcing inward of the chain of ossicles, pressure by this means on the labyrinth-fluid, and thence to the cerebro-spinal fluid (pp. 138, 139).

Adenoid Growths and Granulations in the Nasopharynx.—In a number of cases of chronic aural catarrh, there are found adenoid growths and granulations in the nasopharyngeal space. Their nature and the symptoms they produce have been very carefully studied and described by Czermak, Türck, Semeleder, Voltolini, Löwenberg, and W. Meyer.[2]

These growths are described as benignant in nature, and more or less leaf-like or conical in their shape. They are usually situate quite high in the nasopharynx, are extremely delicate, and hence bleed on being touched. Their height or length rarely exceeds three cm., and their breadth or thickness varies from a few lines in the smallest to one or two centimetres in the largest. As might be supposed, such growths interfere not only with respiration and enunciation, but also with the normal ventilation of the Eustachian tubes and the tympana.

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[1] Outlines of Physical Otiatrics. Translation in Phila. Med. Times, Jan. 4, 1873.

[2] Archiv für Ohrenh., Bd. ii., N. F., S. 129 and 241.

The symptoms are a tendency to bleed whether touched or not, alteration in the pronunciation of certain vocal sounds, as m, n, and ng, and a great change in the facial expression, from the falling in of the alæ of the nose, and the respiration through the mouth, necessitated by the obstruction in the posterior part of the nares. The hearing, too, will in time become greatly lessened from the chronic stoppage in the Eustachian tubes, and the interference to the normal ventilation of the middle ears.

The proportion of aural disease in persons thus affected in the nasopharynx has been placed by Meyer at 130 in 175. Although not uncommonly I find this condition of the nasopharynx, the proportion is by no means similar to the above, a fact to be accounted for, very probably, by the milder climate of Philadelphia, Dr. Meyer having made his observations in the high latitude of Copenhagen. A nasopharynx thus affected is apt to secrete large amounts of tough greenish mucus, the velum may be swollen, and the lower pharynx chronically inflamed. On the other hand, these growths may be present in the nasopharynx without any marked accompanying changes in the pharynx and velum. Not uncommonly, the altered enunciation, respiration, and facial expression arouse a suspicion of their presence, which is subsequently confirmed by rhinoscopic examination, and manipulation with a probe or the finger, the latter causing the growths to bleed.

Symptoms in the Eustachian Tube and Tympanum revealed by Inflation and Auscultation.—Unless there is total occlusion of the Eustachian tube, some air can be forced through it into the tympanic cavity in every case of chronic aural catarrh. To accomplish this, the methods employed may be those known as Valsalva's and Politzer's, or that more direct one, with the catheter and hand-balloon. The sounds produced by forcing air into the drum-cavity are easily heard by means of the auscultation-tube. These sounds, however, are greatly modified by the means used to inflate the drum and by the condition of the Eustachian tube, and, very probably, of the tympanic cavity.

In using the catheter it will be found that its calibre and the column of air forced through it, influence the pitch and quality of the sound heard on auscultation. For, the air passed through the catheter, like every column of air passing rapidly through a pipe, will produce in the latter its fundamental tone, dependent upon the length and diameter of the pipe. Hence, in a wide catheter, a fuller and deeper sound is heard; in a narrower one, a whistling noise. Unless this is borne in mind, the quality of the sound thus produced might be referred to the condition of the Eustachian tube.

Having, therefore, found out, before the catheter is inserted, the general quality and pitch of the sound produced by forcing air through it from the hand-balloon, the surgeon can, with advantage, study the sounds resulting from inflation of the tube and tympanic cavity by the catheter. These sounds will be found to be very different from those obtained even in the same ear by Valsalva's or Politzer's inflation. In the former, there is no instrument employed, which, of course, excludes any sounds from such a source; in the latter, the instrument being so remote from the fauces, no sound produced in the hand-bag is conveyed into the middle ear and thence to the ear of the auscultator. In both of these latter methods of inflation, only the movements of the natural parts concerned and the thud of the entering air are perceived. In that respect they are certainly superior to the Eustachian catheter, since, by their use, the condition of the tube can often be determined without confusing sounds originating in the instrument. The catheter, however, is of the greatest aid and usefulness, if it be but remembered that the quality of the sound made by the air forced into the tube, is influenced by the calibre of the instrument.

Air forced into the normal Eustachian tube and middle ear by artificial means, conveys to the auscultator the impression of air passing with freedom through an unimpeded tube. When the methods of Valsalva or Politzer are used, the air enters with a thud, the ear seems to have been filled by the air sent in, and the impulse thus conveyed upon the membrana tympani reveals itself most distinctly to the ear of the auscultator, joined to the ear of the one operated on, by means of a rubber tube.

Auscultation by the same means, applied to an ear the Eustachian tube of which is narrowed or clogged by the products of chronic inflammation, reveals a different physical condition of the ventilating apparatus of the tympanic cavity. If mucus is present, bubbling sounds will be heard; if the tube is dry, then, of course, a dry sound. At the same time the tube seems narrowed, for the quality of the sound made by the air inflated is that of air passing through a narrow tube.

Air inflated through a normal Eustachian tube enters independently of the act of swallowing; in the tube narrowed or altered by chronic catarrhal inflammation, this act on the patient's part aids greatly in the artificial ventilation of the drum-cavity. So resisting is the diseased Eustachian tube to ventilation, that in some cases air can be forced through only during swallowing. This latter condition is highly characteristic of alteration in the tube.

The Objective Effects of Inflation upon the Membrana Tympani.—The effects of inflation upon the membrana tympani are among the most important objective symptoms. In some respects they have been duly considered, but there are some signs which are deserving of special notice. During Valsalva's inflation the surgeon can inspect the drum-head and the effects produced on it by the motions of the contents of the tympanic cavity. He can also inspect the membrana during Politzer's inflation, if he stand beside the patient and illuminate the previously well-placed speculum, by the forehead-mirror. More or less bulging of the drum-head will be caused by inflation. If the handle of the malleus is held retracted, by alteration in the mobility of the tendon of the tensor tympani, this bulging of the membrane will occur behind and before the manubrium; but if the manubrium is not held in, as above suggested, then it and the membrane will be moved more or less as a whole. At the same time, if there is movable fluid in the cavity of the drum, it will be forced against the membrana tympani and modify the picture presented to the observer. Bubbles may be seen then distinctly through the membrane, or inspissated secretion may be found to change position in the drum.

A most interesting and instructive change, produced by inflation, in the appearance of the drum-head, is the forcing outward of depressed spots or cicatrices. Unless this symptom is sought for, and promptly noted after the air is forced into the tympanum, it may escape notice.

Very often depressed cicatrices are considered retractions adherent to the inner tympanic wall, but on inflation these depressions may not only return to the plane of the rest of the drum-head, but not uncommonly they project beyond it, into the auditory canal, forming thus bladder- or blister-like spots, In some cases these are filled only with air; in other cases, in fact often, they are filled with brownish fluid, which will give them an amber tint. Not only will these appearances come out on the drum-head by inflation, but they can be produced very easily under suction by Siegle's speculum.

This latter method of examination of the drum-head is of the greatest value, for, when the tube is stopped up and absolutely impervious to air, the pneumatic speculum or its equivalent becomes the only means of producing movements in the drum-head, and secondarily of the contents of the drum-cavity.

Not uncommonly inflation of the tympanic cavity, especially by Valsalva's or Politzer's method, produces objective sounds, readily audible without the aid of the auscultation-tube. Especially is this observable when the entire drum-head is flaccid and easily moved to and fro, or when, in a comparatively normally tense membrane, flaccid scars are found.

The sound produced in either instance is that of a loose crackling and flapping of the flaccid tissue. In a case recently observed, so loud was this flapping-sound that it was heard across a large room, not only during Valsalva's method of inflation, but also during rapid breathing through the congested nares, the mouth being kept closed.

Causes of Chronic Catarrh of the Middle Ear.—Very few patients can assign a satisfactory cause for their disease. In fact, it is not an easy task for the physician to discover the positive cause for chronic aural catarrh in the majority of cases. It does seem that very often chronic catarrh of the middle ear is caused by chronic coryza. It would be safer, in most cases, to say that chronic aural catarrh is found associated with, rather than produced by, certain diseases; though the latter may have much to do in its aggravation and chronicity. Thus, chronic catarrh of the ear is frequently observed joined with chronic catarrhal disease of the mucous membrane elsewhere; phthisis; grief and weeping; nursing the sick, especially by night, with loss of sleep; progressive locomotor ataxia; sciatica; general neuralgia, but especially neuralgia of the fifth nerve; insanity; intemperance and debauchery. It may also be found following close upon pregnancy, the menopause, uterine diseases, continued fevers, any of the eruptive fevers, mumps, great shock after fracture of limbs, sedentary life, rheumatism, gout, and, perhaps, secondary syphilis.

Syphilitic Disease in the Middle Ear.—In some instances syphilis apparently causes well-marked changes in the middle ear, which alterations have been very erroneously referred to the nerve-structures of the internal ear, especially to the cochlea. There are many more reasons for placing these apparently syphilitic changes in the tissues of the middle ear, the conductive functions of which we are acquainted with, than in the labyrinthine and nervous structures, of the mechanism of which physiologists know nothing positive. These cases of syphilitic deafness, due to change in the middle ear, are characterized by the suddenness and profundity of the hardness of hearing, as shown by the following case:

On November 16, 1880, Mr. F., 28 years old, a barkeeper in Williamsport, Pa., consulted me at the suggestion of Dr. Nutt, of that city. The patient stated that about four months previous, after going to bed as usual, with perfect hearing in both ears, he got up the next morning deaf in his right ear, which "had roared like a sea-shell," and been deaf ever since. He was a large, fine-looking man, with light hair, fair, rosy complexion, and apparently in perfect health. He admitted having had syphilis and gonorrhœa some years previous. He denied having ever had any cutaneous eruptions or sore eyes. He had been married five years to a healthy woman, but she had never borne children. His physician wrote me that on account of syphilis in this man he had given him iodide of potash and bichloride of mercury, which he was still taking when he consulted the writer. But the hearing had not improved under its use.

Further examination of this case showed that the tuning-fork, vibrating on the vertex, was said to be heard equally well in both ears; that the voice was heard normally in the left ear, but only in close proximity to the right ear, and probably through the bones of the head. The Eustachian catheter, however, revealed on the right side a perfectly and easily inflatable Eustachian tube. An examination of the mouth and fauces revealed no abnormal condition, excepting *two suspicious red warts on the velum to the left of the uvula.* The examination of the right ear revealed a very red fundus of the auditory canal and a deeply congested flaccid membrane and manubrium. While this congestion may have been due to the presence of a firmly wedged plug of cotton which the patient had long worn in the affected ear, it should be borne in mind that both Bumstead and Sexton[1] have noted such congestion as a symptom in syphilitic ear disease.

In addition, the history of syphilis, with the presence of specific warts on the velum, and the sterility of the patient and his wife, together with the sudden, profound, and permanent deafness, without any very definite reasons purely aural, would tend to place this case among those of syphilitic deafness. The two great questions in such a case are: Where is the lesion? and, What is its form?

As the Eustachian tube was perfectly and very easily inflatable by the catheter, and showed no signs of having ever been morbidly closed, we are forced to look elsewhere for the cause of deafness. As the tuning-fork on the vertex was heard in the affected ear, we cannot place the lesion in the labyrinth; we are forced to locate it in the middle ear.

In endeavoring to determine its nature, we must recall the tendency to the formation, in this man, of papilloma or granuloma as shown by the peculiar warts on the velum. In fact, in this case one is strongly reminded of the explanation of similar affections given by Dr. Sexton in the paper quoted, "that it may be surmised that granuloma, or circumscribed, small, round-cell-infiltration takes place within the tympanum, that the invasion is rapid, and that it prevents by fixation the conductive apparatus from its normal movements."

This case seems so well marked in its peculiar features as to warrant its being placed among the syphilitic diseases of the middle ear, a class which Dr. Albert H. Buck proposes to place as class first, in his category of specific cases.[1]

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[1] See paper by Dr. Sexton: Amer. Journal of Otology, vol. ii. p. 301, 1880.

In this country, within the last few years, I have observed a number of cases of chronic aural catarrh traceable to exposure by sleeping on the ground, while in the field as soldiers during the recent war.

Anglo-Saxons born in tropical countries, as well as those whose parents are, one an Anglo-Saxon, the other a native of a tropical region, seem specially liable to chronic aural catarrh. This has been remarked by Hinton, of London, who had large opportunity of seeing such cases among the English with connections in India. In our country I have observed such a tendency in children born of Anglo-Saxons and Mexicans in Mexico and South America.

In these cases Hinton has observed a thinning of the membrana tympani in its posterior segment. In a few cases I have seen, a similar condition of the drum-head was noted. I have observed a number of cases of chronic catarrhal deafness in young women from eighteen to thirty years of age, associated with, and apparently caused by, ozæna and menstrual irregularities; according to my experience, ozæna is more frequent in girls and women than in men.

Hunting, which often brings with it a wetting, and especially duck-shooting, seems to be a cause of chronic aural catarrh in men. Also, diving and ducking the head in cold water most surely produce a thickening of the drum-head and lead at last to a chronic catarrhal state of the tympanic cavity. Mill-hands of both sexes are specially liable to chronic catarrh of the middle ear; as also are carpenters, boiler-makers, and female domestics. In the first class, the noise, the confinement of the work, and the dust certainly tend to produce catarrh of the air-passages, general debility, and aural disease.

Carpenters are constantly exposed to the varying temperatures around a new building; the latter cause, added to their liability to perspire and the fact that they are generally insufficiently clad, makes them very often the victims of aural disease.

Boilermakers' and telegraph operators' deafness may be partly due to nervous exhaustion from continuous shock, but chiefly it is dependent upon catarrhal disease.

Female domestics, and women forced to do their own housework, are constantly exposed to great changes in temperature, because their labor takes them one moment to the hot kitchen and the next moment to the cold court or roof to hang up wet clothes, or from cooking in the house to scrubbing in the open air. To these facts may be added that such women are usually found in damp skirts, and when they rest for a moment it is usually without any covering for the head, at the front door or at a window, in a draught.

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[1] American Journal of Otology, vol. i. p. 29, 1879.

These are some of the more manifest causes; there are other causes assigned by patients, but these are mostly fanciful. Since, however, some of these causes have been given by really intelligent people, it may be well to cite a few: thus, a lady informed me that her deafness, markedly catarrhal, was ushered in by a hasty journey to Europe and back again to America. Two persons of intelligence have assured me that they became deaf in Switzerland, as they thought, from the chilly air, and the damp rooms of hotels. Others attribute their hardness of hearing to blows on or about the ear, excessive night study, editorial work, and sudden noises near the ear, as of firing guns, etc. The latter cause very frequently produces an injury of the labyrinth, but it, like many of the causes given by patients, has only served to call attention to an ear *already* diseased by chronic catarrh. In some cases *no reason* is given; it seems that the patients in such cases have been growing deaf so long that they have become used to it. This is specially noticeable in children who have become deaf, or in adults who became chronically deaf while children.

One might suppose that deafness for which no cause is assigned, would be found in neglected children of the poor. But I have been surprised to find that children of the rich and educated—children well cared for—are frequently placed under treatment for hardness of hearing for which no reason is given by the parents, nor can the latter be assisted by the surgeon in recalling any probable cause. These cases are almost invariably found in families having, apparently, an hereditary tendency to deafness.

CHAPTER III.

TREATMENT OF CHRONIC CATARRHAL INFLAMMATION.

In treating chronic catarrh of the middle ear, the particular form presenting itself, either the moist or the dry, must be kept sharply in mind. It is very evident that grave mistakes have been made in applying empirically one form of treatment, steam, for example, to every case of hardness of hearing which could be attributed in any way to chronic catarrh. A moment's reflection would surely show the folly of using such a remedy in a case of moist catarrh. On the other hand, some such relaxing or softening means may be of value in the dry and sclerotic forms of catarrhal deafness.

The treatment of any case of chronic catarrh of the ear resolves itself very quickly into the question, What will restore the middle ear to its normal condition of containing air and conducting sound? The answer to this will depend upon the power to decide, whether the interference to hearing is due to an excess of secretion in any part of the mucous lining of the middle ear, or to an absence of such a secretion combined with the thickening, stiffening, or drying of any or all the parts concerned in conducting sound. With this divergence in form, or in these different stages if you will, comes a vast divergence in treatment. And, at the outset, it must be confessed that treatment applied to the moist, secretory forms is far more satisfactory to patient and physician than that applied to the so-called dry, ascretory, "proliferous," "chronically thickened," or "anchylosed" forms. Doubtless, many cases have been placed in the latter category, that of the dry form, which really should have been placed in the former class. Among recent authors, Mr. James Hinton, of London, has shown, that a large number of cases formerly diagnosticated as purely dry chronic catarrh of the middle ear, are really cases of inspissated accumulations in the tympanic cavity, and by their removal hearing is restored. Of course, those cases in which masses of fluid behind the drum-head cause the latter to bulge, have long been recognized by aurists, but Hinton, Schwartze, and Weber-Liel claim that many cases of what was once called hopeless thickening and hardening of the drum and its contents, are really very remediable examples of simply hardened old secretions in the drum. Without doubt such is sometimes but not often the case; the great obstacle in the way of their successful treatment is the impossibility of always diagnosticating them. The more fluid these old accumulations are, the more readily are they recognized; the older and harder they are, the more difficult they are of recognition through the drum-head.

Constitutional Remedies and Hygiene.—Constitutional remedies are of the greatest value in the treatment of chronic aural catarrh. They are most efficient when chosen from the list of so-called alterative medicines or alterative tonics. The preferable drugs are, perhaps, iodide of iron, iodide of potassium, and bichloride of mercury. These are especially adapted to the cases presenting strumous features, glandular enlargements, and the decidedly secretory characteristics. In the dry form, I have obtained the best effects by using iron and strychnia, and the combination found most desirable is wine of iron with strychnia (gr. ss–j to f℥iv). The dose of such a mixture should be a teaspoonful thrice daily.

For some time past, internal remedies have fallen into disuse in the treatment of chronic aural diseases; but lately, it has seemed best to return to them, fully aware that they are not to be relied on for all the aid needed, but as admirable adjuvants to the local treatment. Mr. Hinton has advised[1] the giving of perchloride of mercury; this he has given in doses of $\frac{1}{36}$ or $\frac{1}{48}$ gr. two or three times a day, with the perchloride of iron, and he believes this combination is often useful in the dry or proliferous form.

Applications to the Nares, Nasopharynx, and Throat.—Medicated applications to the nares, nasopharynx, and fauces are of great importance in the treatment of chronic aural catarrh. From what has been said elsewhere, it will be seen that from the nature of the origin of this disease in many instances, treatment of the parts just named would be indicated. In by far the vast majority of cases of chronic catarrh, more benefit is derived from the proper treatment of the nares and pharynx than from direct medication of the tympanum. The latter is probably not as often reached by injections aimed at it as is supposed, and, if reached by such substances, is probably more frequently injured than not. In every case of chronic aural catarrh, the lesion in the tympanum either has been, or still is due to want of air in the cavity. This, of course, has been due chiefly to the occlusion, either temporary or permanent, of the Eustachian tube. Such being the case, the treatment must aim either at the removal of this obstruction to ventilation of the tympanum, or to its effects. The latter may have obtained so long as to be irremediable, but the first aim in the treatment should be to restore the tube to its physical function as conveyer of air to the tympanum, and endeavor to check the advance of the disease.

There are, however, some cases of chronic catarrh of the middle ear, in which the Eustachian tube is found to be pervious, both to natural and artificial inflation, and yet the hearing is much impaired. In these cases it will be found that the lining membrane of the tympanum has undergone a change, mostly a thickening, or that the conductors of sound in the tympanic cavity have become stiffened by the chronic disease in the mucous membrane.

Although the tube is found pervious in these cases when examined by the surgeon for the first time, there must have been a period in the history of the process when the tube was stopped up and thus aided in bringing about the condition of the drum-cavity just mentioned.

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[1] Op. cit., p. 243.

It may be said, therefore, that these two chief forms, viz., (*a*) a closed tube with an empty tympanum, and (*b*) the pervious tube with a sclerotic tympanum, are classes into which chronic aural catarrh may be placed. A third class (*c*) may also be found in which inspissated matter is retained in the tympanum, because the tube is closed. If fluids ever can be or should be thrown into the tympanic cavity, the class *c* would afford the proper occasion.

Direct Medication of the Nares and Nasopharynx.—Direct medication of the nares and nasopharynx may be best accomplished by instillations, by applications conveyed into these parts, on cotton twisted fast to the end of a cotton-holder, and by sprays. Instillations into the nares may be entrusted to the patient, and form a valuable adjuvant to the local treatment by other means, carried out by the surgeon. In this manner from three to five drops once or twice daily may be dropped into the patient's nostrils by himself or an assistant. All aqueous solutions must be warmed before they are instilled into the nose. If only one nostril, and the tube and ear on that side are affected, the treatment may be limited to that side. The solutions best adapted for instillation are Dobell's solution,[1] chlorate of potash (gr. iv to f℥j water), solution of sulphate of zinc (one grain), or sulphocarbolate of zinc (gr. v to f℥j water), and weak solutions of nitrate of silver (one-half to one grain to the ounce of water). Fluid cosmoline, alone or combined with boric acid (four grains to the ounce), is also an efficient and agreeable preparation for instillation. It need not be warmed.

The hypertrophied mucous membrane of the turbinated bones, especially that of the inferior turbinated bone, may be touched with a mixture of iodine and glycerine in equal parts, or with the compound iodine mixture, composed of potass. iodidi 0.50 grammes, tinct. iodinii 5.00 grammes, aq. destill. 10.00 grammes. These affected parts may also be touched with solutions of nitrate of silver, 1 to 5 grains to the fluidounce of water.

When the anterior hypertrophies of the turbinated bones are to be touched, the nostrils must be dilated either by Kramer's speculum, or by a short hard-rubber nasal-speculum very similar to a wide, short aural-speculum. The latter remains in position by itself; the former must be held by the surgeon. The illumination should be by the forehead-mirror. The medication to be applied is then conveyed to the anterior hypertrophy, or it may be carried along the entire length of the inferior turbinated bone to the posterior part of it, or to the posterior pharyngeal wall. Care should be taken not to touch the under edge of the turbinated bone, nor the floor of the nose, as these parts are very sensitive. Hence the cotton-dossil must not be dripping, nor too large. Neither must it be soaked, for in that case, if it is squeezed, excess of fluid will fall from it upon these sensitive parts, as it is passed or pressed upon the less sensitive side of the turbinated bone. In all forms of medication of the nares, nasopharynx, Eustachian tubes, and fauces the prime consideration is not to irritate. If the surgeon cannot cure, he must, at least, be careful to make no worse. Arrest disease, benefit the hearing if possible, but be careful not to retard nor to make worse chronic catarrhal processes in the nose and ear. I must refer to purely rhinological sources for directions for treatment of posterior hypertrophies of the turbinated bones, adenoid growths, polypi of the nose, and major operations on the nasopharynx.

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[1] Dobell's solution consists of sodæ bibor. and sodæ bicarb., aa gr. ij; acid carbol. gr. j; glycerinæ fʒj; and aquæ f℥j.

Hand-atomizer.—One of the most convenient, efficient, agreeable, and, at the same time, one of the safest ways of applying medication to the nares and nasopharynx is by means of the hand-atomizer. With this instrument the surgeon may convey into the diseased cavities of the nose and pharynx in the simple rhinitis, which so often accompanies and promotes chronic aural catarrh, the spray of the following mixtures:

℞.—Zinci sulphocarbolat., gr. v.
Listerine (Lambert's), fʒij.
Aquæ, fʒvj.—M.

Or,

℞.—Zinci iodidi, gr. v.
Listerine (Lambert's), fʒij.
Aquæ, fʒvj.—M.

If there is any accumulation of mucus which the patient is not able to remove by blowing his nose, the nares may be sprayed with the following:

℞.—Sodæ bicarb.,
Sodæ bibor., āā ʒss.
Listerine (Lambert's), f℥j.
Aquæ, f℥iij.—M.

The spray of the distillate of hamamelis will be found agreeable and efficient in acute rhinitis, as well as the spray of Dobell's solution.

In the more chronic and hypertrophic forms of rhinitis, the spray of the following mixture will be found very efficient:

[1]℞.—Iodinii cryst., gr. iv.
Potass. iodidi, gr. x.
Zinci iodidi,
Zinci sulphocarbol., āā ℈j.
Listerine, f℥j.
Aquæ, f℥iij.

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[1] Dr. Lefferts, Phila. Med. News, May 3, 1884.

The local applications, as here set forth, may be made by the surgeon two or three times a week. They should be followed by inflations of the tympana by Politzer's method, or by the Eustachian catheter.

These applications may be supplemented by instillations into the nose, by the patient at home. When iodine preparations are applied to the nares, by means of the cotton-holder, the sprays should be thrown into the nose thereafter.

Irrigation of the Nasopharynx by means of the Nasal Douche.—Any form of irrigation applied to the nasopharyx may be called a nasal douche. But this name is specially applied to an instrument devised by E. H. Weber, during his physiological studies on the velum and pharynx.

It consists of a bottle to the lower part of the side of which a hose is attached. The latter has a nose-piece, best made of glass, olive-shaped, which fits snugly into one nostril. In this country and in England, such an instrument is usually called Thudicum's nasal douche, after him who introduced it to the notice of the profession in the latter country. It is, without doubt, the best means surgery possesses of irrigating the nares and nasopharynx. Accidents to the ear have happened by *improper* use of the nasal douche. When it is carefully and correctly applied, however, I do not know that water has ever been forced by it into the middle ear. The use of the nasal douche should be *limited*, however, to the treatment of ozæna, or fetid nasal catarrh, and to irrigation of these parts after operations on them.

The following rules will be found to give the greatest assurance of safety, if most strictly adhered to. And, so far as I have observed, no accident has ever happened where they have been fully observed:

1. The vessel containing the fluid to be injected must not be higher than the forehead of the patient.

2. The forehead must not be inclined forward too greatly, for if it be, the fluid enters the frontal sinuses; nor must the head be thrown backward. The upright position is the only safe one.

3. The fluid used in each case must be tepid, and in bad weather the patient should not leave the room for a quarter of an hour after the use of the douche.

The discovery of the nasal douche is attributed to E. H. Weber, while he was making his experiments on the organs of smell. According to Dr. Seyfert,[1] Theodore Weber, of Halle, was the first to utilize the fact that a stream of water passed through one nostril will escape through the other, after passing through the nasopharyngeal space. This is due to the well-known reflex action of the velum palati, which causes it to retract and shut off the nasopharynx from the pharynx.

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[1] Ueber die vielfache Anwendung des Irrigationsapparats, Wiener Med. Presse, Nos. 33, 34, 36, 1872.

A universal mistake of physicians and patients is to place the vessel holding the fluid at a very great height above the head. The surface of the fluid in the douche-bottle must have only that elevation above the nose sufficient to carry the irrigation into the nasopharynx. If the vessel is held or placed higher than this, it is plain that the fluid used may be forced too high, even into the frontal sinuses and tympana.

Before the nasal douche is used by the patient, the surgeon should satisfy himself that there are no obstructions to the passage of the water through either nostril. An obstacle to the return current of the irrigating stream would be just as dangerous as too high a position of the source.

Patients often ask how much fluid they are to use in the douche, and how long the current should be allowed to flow through the nares without being interrupted? To the first question, it may be said that half a pint is enough to begin the use of the douche with; the amount can be increased gradually as the patient becomes better practised in the use of the instrument. The second question is more important, and to it the reply may be given that at first the current must run but a short time through the nares without interruption, say during the short holding of the breath. Gradually the patient learns to breathe comfortably through the mouth, while the current of water runs through the nares. When proficiency in this respect has been attained, perhaps an entire pint or even more may be run through the nostrils and nasopharynx without interruption. But at the outset of the employment of this apparatus, the patient must be told of the importance to him of not gasping or gulping during the operation. The latter danger is most easily avoided by allowing the current of fluid to run through the nares only as long as the patient can quite comfortably hold his breath.

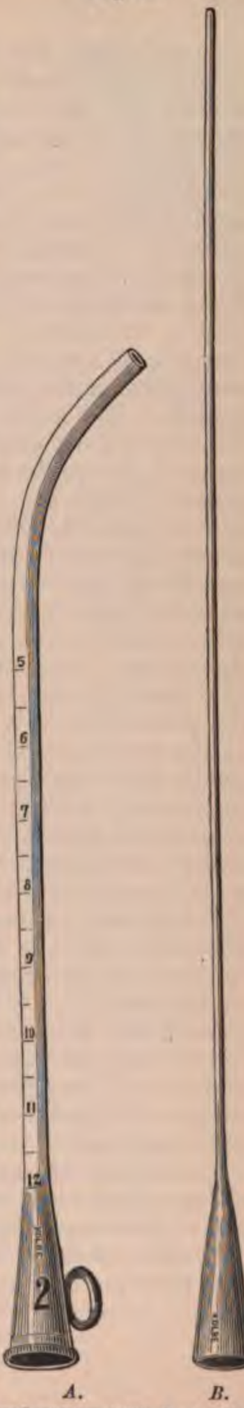
In the warm water used in the douche, all that will be most usually necessary at first will be common table-salt, in the proportion of 56 grains to the pint of fluid. In many instances I have found it very beneficial to use a preparation of salt known as "sea-salt." This is said to be the result of evaporation of sea-water; it surely is stronger to the taste than common table-salt, and doubtless contains more haloid elements.

In ozæna, in addition to the common salt, a few drops of a strong solution of permanganate of potash may be thrown into the water, until the latter becomes impregnated with it. A thirty-grain solution of this drug may be written for, and the patient instructed to use about 10 to 20 drops to the pint of water. The use of a nasal syringe is entirely reprehensible, from the uncertainty of its pressure, even in the surgeon's hand.

Applications to the Eustachian Tube.—In most cases of swelling and narrowing of the Eustachian tube, the use of inflation simply will be quite sufficient to overcome the obstacle. If, however, after the catheter is known to be properly placed in the mouth of the tube, no air is forced into the tympanum, the tube may be considered occluded, and resort may be had to the careful use of a probe of catgut, laminaria, or whalebone. Perhaps the most desirable form of bougie for this purpose is the small catheter-bougie of Weber-Liel; it is best employed with a graduated catheter devised to go with it. All bougies or probes, for use in the Eustachian catheter and tube, should first be fitted into the catheter, and marked at two points, on that end nearest the surgeon. The first point should correspond to the exact length of the catheter used, which will indicate when the distal end of the probe is about to leave the beak of the catheter and enter the tube; the second point should be as distant from the first as the length of the amount of probe it is desired to push into the tube. This may vary from one to one and a half inches. Inflation should be done as thoroughly as possible *before* the probe is inserted, never afterwards, for fear of emphysema. Even the most gentle manipulation may abrade a diseased mucous membrane, and then an inflation might produce the above-named complication.

Various applications have been advised and made to the mucous lining of the Eustachian tube, in order to allay chronic inflammation. In most cases they do more harm than good; beyond weak solutions of bicarbonate of soda (gr. v–f℥j), and sulphate of zinc (gr. j–f℥j), all injections into the Eustachian tube are of risk. Steam is not to be considered anything more than useless; it is not harmful, unless carelessly applied, when the patient may be scalded.

Fig. 89.



Weber-Liel's graduated metallic Eustachian catheter *A.*, for passage of the small bougie-catheter of gummed silk B.

In all cases, the fluid injected either into the mouth, or further into the calibre of the tube, should be warmed. Great benefit may result from making various applications to the mouth of the tube, but no further inward, in chronic catarrh of the middle ear. In this way, applications to the nares and nasopharynx act in this disease. Much good may be thus done by touching the faucial region of the tube with nitrate of silver in solution, or the various solutions named on p. 395. In order to accomplish this, the medication may be applied along the inferior turbinated bone until the posterior pharyngeal wall is touched, or an aluminium cotton-holder, such as is found in all surgical instrument-makers' shops, may be made to gently and cautiously carry up behind the velum the fluid to be applied. The point of the probe in the latter method may be directed toward either tube, or, if both tubal mouths are to be touched, the probe may be held in the median line, behind the velum. Then the natural reflex action of the pharyngeal and palatal muscles will tend to bring the mouths of the tubes toward each other and the probe, lying in the median line. Such a mode of application is especially necessary when granulations or ulcers exist in the nasopharyngeal space. Such a condition may exist without any marked disease in the pharynx below the velum. Sometimes the first real indication of its existence is obtained by the blood found on the cotton-tuft at the end of the probe when it is withdrawn from the nasopharynx.

The treatment of adenoid and polypoid growths should consist in their evulsion or cauterization, and in subsequent applications of astringents to the nasopharyngeal space. The mechanical destruction of these formations, however, is painful and inconvenient, while their cauterization is simple, and in most cases all that is needed.

It has been proposed by Dr. Meyer,[1] to crush and tear these adenoid bodies by means of an instrument, somewhat like a lithotrite, to be introduced through the nares. An index-finger of the surgeon is to be inserted at the same time through the mouth and behind the velum, so as to direct these growths between the prongs of the crushing implement. But in many cases it will be necessary only to wound these growths with the finger, or a probe armed with a large tuft of cotton, and then apply a solution of nitrate of silver to the nasopharynx, by means of the last-named instrument. After the application of silver, which may be in strength varying from 10–20–30 gr. to f℥j of water, astringent, demulcent, or detergent solutions may be employed by means of the atomizer or nasal douche. Salt and water, in the proportion of fifty-six grains of the former to a pint of the latter, will usually be all that is required after the use of nitrate of silver, but if a stronger fluid appears to be demanded, sulphate of zinc, in the strength of gr. i–ij to f℥j of water, may be used, and, if there is an offensive odor to the discharge from the nares, solutions of permanganate of potash may be employed as already directed (p. 398).

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[1] Archiv f. Ohrenh., Bd. ix.

Politzer[1] finds that in cases of adenoid growths in the nasopharynx, which bring about swelling and closure of the mouth of the Eustachian tube and hardness of hearing, touching the affected parts with nitrate of silver is more effectual than cutting or dragging away the new growths.

Excision of the Tonsils.—This operation I consider rarely, if ever, necessary for the relief of hardness of hearing or deafness, simply because the altered function of hearing is in no way dependent on the tonsillar enlargement.

The larger tonsil is often on the side of the better ear; sometimes on the side of a perfectly normal ear, and very often enlarged tonsils are found in those with perfect hearing.

When enlargement of the tonsils is associated with deafness, they are to be regarded simply as symptoms of a catarrhal condition which has also brought about alteration in the glandular structures of the nasopharynx, Eustachian tube, and in the middle ear. Their violent excision (and excision is always violent) is worse than useless—it is positively harmful and always alarming.

I am furthermore convinced of the futility of excision of the tonsils for hardness of hearing, because the *largest tonsils* I have seen were the successors of excised ones. They might almost be regarded as recidives of a morbid growth, like those succeeding fibrous tumors of the lobule. The remedies for the other catarrhal symptoms are usually beneficial to the enlarged tonsils.

Clipping the Uvula.—In some instances an elongated uvula keeps up a constant irritation of the fauces and posterior wall of the pharynx, thus contributing to an aggravation of an aural catarrh. All that is required in such cases is to clip off the redundant mucous membrane, carefully avoiding an ablation of the muscular part of this important appendage to the velum. A removal of such a fold of mucous membrane is generally stimulation sufficient to excite the rest of the uvula to contraction. The entire removal of the uvula is as reprehensible as it is common. Gargles alone will often contract the uvula.

Gargles.—One of the simplest and best gargles in the pharyngitis which usually attends chronic aural catarrh, is a saturated solution of chlorate of potash. Another highly useful and more astringent one, is the rhus glabrum gargle, as prepared by H. C. Blair's Sons, of Philadelphia. Its formula is:

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[1] Zur Therapie der mit adenoiden Vegetationen im Rachenraum complicirten Erkrankungen des Mittelohrs. Archiv f. O., Band x. S. 55.

℞.—Potass. chloratis, ʒij.
Ext. fl. rheos glabri,
Glycerinæ, āā f℥j.
Aquæ, f℥vj.—M̄.

Another very elegant gargle is prepared by Sayre, of Philadelphia, as follows:

℞.—Glycerite of sumach,
Tinct. pomegranate bark, āā f℥iv.
Infus. rosæ comp., q. s. f. Oj.

The usefulness of gargling consists, not only in healing the mucous surfaces, but also in the gymnastic effect on the velum and muscular structures of the Eustachian tube, which it brings about.

Applications to the Cavity of the Drum.—That which was said against applications to the cavity of the Eustachian tube may be repeated here. Few applications which are aimed at the tympanic cavity ever reach it. If they did, they would probably do more harm than good. To render the Eustachian tube pervious to air, and hence to ventilate the drum-cavity, is more important than to inject fluids into it, unless, the membrana tympani being perforated by disease, a means of escape of medicated fluids is afforded.

Vapors of iodine, ether, or chloroform may be of assistance in stimulating a delicate but diseased mucous lining, but it would be just as wise to fill, with a fluid, an air-vesicle in the lung by the way of a bronchial tube, as to fill up the tympanum, if one could, by injecting fluids through the Eustachian tube, in chronic aural catarrh, unless there is evidence of inspissation of mucus in the drum-cavity. In such cases, weak and warm solutions of bicarbonate of soda (3–5 gr. to f℥j) are of service. But even with these, great caution must be observed. In all cases in which injections thus directed have apparently produced good results, I have felt inclined to ascribe the benefit to the gentle stimulation and ventilation of the Eustachian tube, rather than to the direct contact of the injected fluid with the cavity of the drum. The latter is an air cavity, and resents the presence of medicating fluid.

Operations with the Knife on the Drum-head.—When it has been found impossible to send into the tympanum as much air as seemed demanded, resort has been had to the knife. And the mere incision, with the subsequent admission of air to the drum, has had much more to do with the good result than the choice of the particular spot of the operation. This is proven by the well-known fact, that, no matter where the perforation is made, the hearing, which at first has been increased, has diminished as soon as the opening in the drum healed. And this, as every surgeon knows, occurs sometimes even in a few hours.

Space forbids my entering upon the history of cutting operations on and through the drum-head.

The proposal of the operation of cutting through the membrana tympani is supposed to have originated with Johannes Riolanus, of Paris, in 1650; Sir Astley Cooper, one hundred and fifty years later, performed the operation in several cases, with apparent success, but subsequently abandoned it on account of his want of encouragement. About seventy-five years before Sir Astley Cooper's operations on the drum-head of man, Cheselden perforated the drum-heads of dogs, and believed that the latter were not only not made deaf by it, but that they became more sensitive to some sounds. In the latter part of the eighteenth century, the operation appears to have fallen into the hands of quacks, and to have been disregarded by the regular practitioners: a reaction too often found when the latter, in their enthusiasm, make use of an operation in a multitude of cases, whether suitable or not.

The indications for the operation had been very vaguely given up to 1800, when Himly in Germany, and Sir Astley Cooper in England, proposed to make use of the operation of perforation of the drum-head in closure of the Eustachian tube. Cooper operated in a number of cases, with a variable success; but as he operated rather empirically, simply for deafness arising from closure of the Eustachian tube, a condition he does not seem to have been fully able to diagnosticate, he soon ceased to obtain results as good as those he first appeared to have obtained, and he then abandoned the operation entirely. Again, the unfortunate reaction in the minds of the regular profession, and naturally enough, again the operation is found almost entirely in the hands of quacks, with not only no good results, but apparently most disastrous ones. Himly showed that the operation, when it had proven of benefit, was in exceptional cases of deafness due to hermetical closure of the Eustachian tube. But the operation ceased to be regarded with favor, because it had been widely and ignorantly applied; and Wilde is found obliged to speak in defence of the operation, since some had condemned it as dangerous to life—which, however, they could not prove.

It at last became fully established by the operations of Cooper, Itard, Saunders, Schwartze, Hinton, Politzer, and others, that it is highly necessary and entirely safe, to perforate the membrane of the drum, in order to remove from the drum-cavity any fluid or semi-solid accumulation, which cannot escape or be forced out in any other way.

But, as a great demand has ever been, and still is, made on the aurist for relief from chronic, neglected catarrh of the middle ear, without fluid accumulations in the latter, but with every symptom of sclerosis and retraction of the membrana tympani and even of deeper parts of the sound-conducting apparatus, assistance has been sought in various forms of incision and excision of the membrana tympani; in the maintenance of permanent perforations in it; and in tenotomy of the tensor tympani muscle.

Various forms of incision and excision of the membrana tympani for the relief of hardness of hearing *not dependent on accumulations of fluid in the tympanum*, but upon chronic thickening, hardening, stiffening and retraction of the membrana tympani and other parts of the sound-conducting apparatus of the middle ear, have been proposed by several authorities. The operations about to be named have been undertaken with no empirical intent, but with a knowledge of a clearly diagnosticated condition of the auditory apparatus. This must be said of them as preëminently distinguishing them from previous operations on the drum-head; though the best results of paracentesis membranæ tympani are obtained when fluid has collected in the drum-cavity. When the membrana tympani is indrawn, Lucæ and Politzer have proposed *to incise the folds of the membrane.* Gruber has advocated repeated prickings or incisions, and even excision of parts of the drum-head (myringectomy). Excision of the handle of the malleus, the chief object being to retain a permanent opening in the membrana tympani, must be deprecated.

Repeated incisions through cicatrices, or an incision through the posterior fold of the membrana tympani, most surely lead to good results in many cases of progressive hardness of hearing. In the former instance the benefit is due to the tightening of the previously flaccid part of the drum-head, which ensues with the healing of the cuts; in the second instance the drum-head, already too tightly stretched, is freed, and very often it and the chain of ossicles will swing more freely in consequence of this simple operation. With the head of the patient gently supported, and the canal properly illuminated, by light reflected from the forehead-mirror, the incisions may be made best with a spear-headed knife, the shaft of which should be six cm. long, and curved at an angle of 45° from the hard-rubber handle.[1]

Similar procedures are recommended by Gruber[2] for the correction of anomalies in tension of the membrana tympani. The same authority has also suggested the excision of a piece of the drum-head by means of an instrument arranged especially for the operation.

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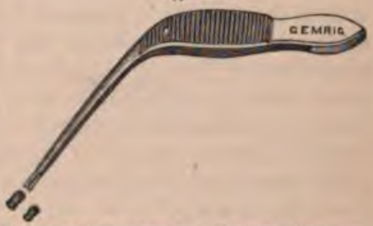
[1] Politzer, Wiener Med. Wochenschr., 1871, Nos. 1 and 2.

[2] Lehrbuch, pp. 581, 582.

The great aim of otologists, from the time of Paroisse to the present moment, has been, and still is, to make and retain a perforation in the membrana tympani, in a manner at once simple and free from danger. If such a perforation could be obtained, it has been supposed that the hearing, in many cases of chronic aural catarrh, would be improved. To attain this end, numerous suggestions have been made: as, to keep the perforation open by means of a triangular-shaped sound (Paroisse); to insert into it a bougie (Saissy), or, small solid or hollow bodies (Philippeaux and Frank); but as they have proven of no value, it will be better to confine the attention to the few exceptional forms which have seemed to offer a reasonable hope of aid.

Sometimes an artificial perforation in the drum-head is retained by means of a small, hard rubber eyelet, as suggested by Politzer.[1] The eyelet, with a furrow on its outer surface—its general shape being that of a miniature barrel—is fastened to a piece of fine silk or cotton thread, and then inserted into a small cut in the membrane, at any chosen point, by means of special forceps (Fig. 90), or by those represented in Fig. 83. The thread attached to the eyelet provides a means of pulling it from the ear, when such a procedure becomes necessary. If the eyelet becomes clogged with dried mucus, Politzer has found that a drop of glycerine, placed in it by means of a Pravaz syringe, will soften such an obstacle and permit its being removed by means of a stiff bristle.

Fig. 90.



POLITZER'S EYELET AND EYELET FORCEPS.

Politzer has found that in many cases the eyelet is borne without any inflammatory reaction in the drum-head or tympanic cavity; yet in some instances, the good result of the operation has been nullified by the irritation in the ear consequent upon the introduction of the eyelet. Since, in several cases in which the eyelet set up inflammation, sharp projections were found on it, the necessity of making the eyelet perfectly smooth before it is put into use becomes apparent.

I have performed this operation with entire success, with temporary improvement in hearing. But the perforation in the membrane healed in a few weeks and pushed the eyelet out into the canal, and the hearing receded.

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[1] Wiener Med. Wochenschrift, 1868 and 1869.

Another method of retaining a permanent opening in the membrana tympani has been suggested by Voltolini,[1] of Breslau. It consists in making a long incision both in front of and behind the manubrium, and then encircling the latter with a tubular ring of fine gold. The latter is about 2½ mm. in diameter, and is so constructed that when its two free ends are brought together on the inner side of the drum-head behind the malleus, they do not fit closely together but permit of a passage of air into the tympanum, which is further insured by an opening in the canule on the outer side. The latter opening marks the hinge-like division in the canule, and is opposite the point of junction of the free ends. Into the calibre of each half of the tube at this hinge- or joint-like point, Voltolini passes the delicate and flaring pointed-ends of specially devised forceps, by which the canule is pressed into its circular shape after its free ends are brought behind the manubrium. But necrosis of the manubrium having resulted from this manipulation, it would seem that this procedure could not be of universal application when a permanent opening in the drum-head is to be obtained.

Aluminium, being of specific gravity lighter than that of gold, has been substituted by Voltolini in the manufacture of the tubular ring.[2]

It has been proposed, by Weber-Liel,[3] to make a cicatrix in the membrana tympani, at its inferior posterior quadrant, by means of the galvano-cautery, and in the spot thus deprived of its regenerative power, to make an opening, with the hope that such a perforation would persist. By this method, a perforation has been maintained for three and a half years, with the greatest improvement in the hearing.

In a number of cases of chronic otitis catarrhalis, with little or no opacity of the membrana tympani and with a pervious Eustachian tube, Simrock has resorted to puncturing the drum-head by the application of sulphuric acid, usually to a spot on the posterior half of the membrane. The method is said, by its proposer, to be not at all hazardous, as a very little acid will produce all the desired effect, and be entirely under control. The acid is applied to the desired spot by means of a tuft of cotton on the end of a probe, and an opening is effected almost instantly by gentle pressure of the probe point, or by smearing the acid carefully over the membrane at a circumscribed point; the tissue is rapidly destroyed, and the hole is cleared by lifting away the dead substance. The asserted advantages of this method are the rapidity and permanence of its effects. Of seventeen orifices thus made, three remained open for four months. In three cases slight inflammation of the middle and external ear occurred, but without serious complications. Hearing for conversation improved markedly in six; less so in four; no improvement for hearing in seven. Of seventeen cases the tinnitus disappeared in five; in nine it was much diminished; in three unimproved. "After the perforation has thus been made, the ear should not be syringed even if slight discharge occur."[1]

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[1] Monatsschrift f. Ohrenh., No. 3, 1874.

[2] See Weber-Liel, M. f. O., No. 4, 1875.

[3] Eine persistente Œffnung im Trommelfelle. Dr. Weber-Liel, M. f. O., No. 2, 1871, and No. 4, 1875. Also "Progressive Schwerhörigkeit," p. 185, 1873.

I have never employed either of these two last-named methods, nor, in fact, any method, excepting by Politzer's eyelet, to retain a *permanent* opening in the membrana tympani. The latter structure is emphatically a protection to the mucous lining of the drum-cavity, and rather than incur the probability of a suppuration in the middle ear by exposure, I have refrained from that which would be unlikely to prove of great help to the hearing, but which might be very apt to excite inflammation in the drum-cavity.

Tenotomy of the Tensor Tympani.—In 1868, Dr. Weber-Liel,[2] of Berlin, acting upon a suggestion of Hyrtl, invented the operation of tenotomy of the tensor tympani, for which he devised a special instrument, his so-called "hook-knife.[3]

At various times since then Dr. Weber-Liel has published articles on this subject, setting forth the indications for, and the manner of this operation, together with the results of it, which he claims are in the main advantageous.

His views have met with warm support by some, but with entire opposition by others, on the other side of the Atlantic. In America the operation has been regarded with caution; a few have performed it and published their results; but on the whole, the operation has not afforded here the aid, in treatment of progressive hardness of hearing, which it appears to have done in the land of its origin. Carl Frank, the late Dr. R. M. Bertolet, Gruber, J. O. Green, O. D. Pomeroy, Schwartze, A. Hartman, and others, have performed the operation, but at the present time the operation has fallen into disuse.

Removal of Fluid and Inspissated Matter from the Cavity of the Drum, and Eustachian Tube.—Before inflation of the tympanum provided the surgeon with an efficient and harmless method of clearing the Eustachian tube, it was customary to inject bland fluids into the tube. The stream thus forced into the middle ear was found to be most efficient when it could escape by the external auditory canal.[1]

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[1] New York Med. Record, March 27, 1875.

[2] Monatsschrift f. Ohrenh. No. 4, 1868; No. 12, 1868; No. 10, 1870; No. 11, 1871; No. 12, 1871; No. 1, 1872; No. 3, 1872. Vortrag: Berliner Medicinische Gesellschaft, 8 Juli, 1874. See Virchow's Archiv, Bd. 62.

[3] Hakenmesserchen.

Mr. James Hinton, of London, believed that mucus often became hardened in the tympanic cavity, behind an intact drum-head, and, giving to the latter a white, opaque appearance, led to a diagnosis of thickening of the membrana tympani. To obviate the deafness in such cases, he made an incision 2–3 lines long in the drum-head, behind the malleus, and then forcibly injected, from the external auditory canal, a warm solution of bicarbonate of soda. He laid great stress on the hermetical fitting of the nozzle of the syringe into the meatus. I have never found this procedure necessary in this country, where I believe inspissation of mucus is less likely to occur than in more humid and colder climates. It is not uncommon in syringing an ear affected with chronic discharge, to find that the water passes into the nares.

This is no disadvantage if it is produced by gentle syringing, but forcible syringing in any case in which there is an opening in the membrana tympani, must be regarded with caution, since a force thus applied with a view of carrying matter through the Eustachian tube into the pharynx might throw some of the injected fluid into the mastoid cavities and set up irritation there.

Accumulation of fluid in the tympanic cavity and the best means for its removal are illlustrated in the following cases:

Case I. *Brownish Transparent Fluid in the Tympanic Cavity, visible only through a thin depressed Cicatrix; Incision and total Relief.*—Dec. 1, 1875, Dr. A., 80 years old, a hale, hearty man, single, of an extraordinarily well-preserved constitution. Patient stated that for a month, since a cold in his head, he had noted a failure of hearing in the right ear. He was liable to accumulations of ear-wax, according to his statement, and had had his ear syringed, on the supposition that the deafness was due to inspissated cerumen. But no relief was thus obtained. On examination of the ear, the membrana tympani appeared rather opaque, excepting at the upper and hinder quadrant, where it was thin and depressed, and through which the incudo-stapedial joint was plainly visible. This thin, depressed quadrant was markedly of a dark, brownish-yellow color; the rest of the membrane was opaque and gray. Under Siegle's pneumatic speculum, it swelled out into a bladder-like protuberance, and seemed to be filled from behind with a dark, yellowish-brown fluid, as the air was exhausted by the speculum from the auditory canal. The hearing was about a foot for the voice and $\frac{1}{60}$ for the watch. The tympanum could not be inflated by any method, as the Eustachian tube was markedly occluded by the remnants of the catarrh. The patient also stated that the Eustachian tubes were never easily inflated by Valsalva's method; in fact, he doubted whether they were of the average width. No form of inflation caused any alteration in the appearance of the depressed spot, which moved so easily under the Siegle speculum. Incision of this spot gave instant escape to some brownish transparent serum or mucus, and suction with the Siegle speculum brought out a good deal more, in all about twenty to thirty drops. The hearing immediately rose to about the normal grade. Voice and watch were heard easily thirty feet. In the course of a week, as was to be expected from the swollen state of the Eustachian tube, the tympanic cavity filled again. Paracentesis of the same thin spot gave vent to about the same quantity of fluid, and the hearing again went up. In the course of another week, a slight return of "muffled feeling" in the ear, which was relieved by incision and escape of a small amount of fluid. At this visit the Politzer bag forced the Eustachian tube open, and there was no further return of deafness. On March 30, following, I examined the membrana tympani, and found that the thicker part was more shining, and the thin spot, though depressed, was not discolored by any brownish fluid in the drum-cavity. Hearing normal.

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[1] Rau, op. cit., section 210.

CASE II. *Re-accumulation of Mucus in the Tympanum.*—July 1, 1874, Jacob Y., aged 55 years, single, American, furnace-maker, a healthy, spare man. Not very strong. Seemed to be a man of more than ordinary intelligence for one in his position. He stated that for a year or more past, he had noted a gradual diminution of hearing on the left side. The right meatus auditorius was occluded as described on page 305, on which side the tuning-fork, when vibrating on his vertex, was best perceived. The case had been treated by several physicians as one of ordinary chronic catarrh of the middle ear. The drum-head had been said to be thickened, the catheter had been used to inflate the tympanic cavity and to convey various fluids into the Eustachian tube. This treatment, he said, always produced a temporary improvement in the hearing.

When I examined the ear, the membrana tympani appeared thickened, and resembled in general, the opaque lustreless drum-head of chronic catarrh. The hearing for the watch was about $\frac{4 \text{ in.}}{60 \text{ in.}}$. I also inflated the middle ear by means of the catheter, several times a week for a month. Each inflation improved the hearing a little, but in a few hours it sank back again to its low point. The inflations were repeated from time to time for a few weeks longer, with always some improvement in hearing.

On the 12th of September, the patient came with the statement that the benefit of the catheter, though marked, was only temporary; that he constantly felt something like a drop of fluid moving in his ear whenever his head was moved, and that whenever he lay down he heard better. He had told me this before, but I paid no heed to it. But it was now discovered that when he reclined, the hearing really became better, as was shown by testing with a watch. This seemed to point to movable fluid in the drum-cavity, and consequently it was proposed to the patient that the drum-head should be incised. This being acceded to by the patient, a puncture was made in the posterior inferior quadrant of the membrana tympani, and there instantly escaped, on inflating by Valsalva's method, about twenty drops of a brownish, transparent, serous fluid, with some streaks of opaque mucus. But its presence had been in no way, as far as I could discover, indicated by any appearance of the membrana tympani. The hearing rose from one inch, to five feet, for a watch. The membrana tympani became more concave, and of a bluer hue; before the incision it was flat and steel-gray. The hearing, thus regained, remained unimpaired until March, 1875, when, after taking a cold, the symptoms returned in the ear. In this instance there was rather a sense of fulness than of movable fluid. A paracentesis in the same spot restored the hearing, giving vent again to a similar thinnish fluid, nearly transparent, and tinged with brown.

By the 23d of the same month the ear filled up again. The membrane was again perforated, as it resembled the membrana tympani in the previous conditions; though I do not pretend to say that a dark-grayish color of the drum-head indicates mucus or serum in the tympanic cavity. The perforation gave vent to the same kind of brownish fluid, strongly suggestive of extravasated serum from the capillaries of the tympanum. The hearing instantly rose to its relatively normal point.

By the 15th of April following, the same symptoms of muffled hearing returned, and the membrana tympani seemed flattened somewhat, but not enough to attract the attention of one entirely unacquainted with the case, and not on the lookout for changes in the membrane. The color of the drum-head might be said to be dark gray. After the incision it always assumed a light bluish-gray color. Again the paracentesis of the drum-head was resorted to, and after the *usual* brownish-red fluid escaped, the hearing returned.

Again, on May 8, the same note was made, and again on June 8. Then perfect immunity from aural trouble until Sept. 8, when the symptoms returned, but relief was obtained as above. Again, on October 26 and November 24, the membrana tympani was punctured, which completed the history for 1875. On January 3, 1876, the hearing had become again dulled, the condition being soon recognized by the patient, who came to have his ear operated on again.

The incision was made with just the same results as above, and then again on February 19, and on March 28.

Only once, February 19, were bubbles in the tympanum visible behind the membrane. On Valsalva's inflation they moved very markedly. The quantity discharged in this instance was less than on previous occasions. In every other instance there was nothing to call special attention to the presence of fluid in the drum; and this circumstance leads one to believe that many such cases are treated as chronic catarrh, and regarded as gradual sclerosis of the tympanum, because there is no special change on the drum-head indicative of fluid in the tympanic cavity. As the fluid gradually gets harder, the case is abandoned as hopeless. This would seem to be avoidable in some cases, judging from this and others, by incising the membrane, at least as a last resort, even when the case resembles those of so-called dry catarrh, with thickening of the tissues of the tympanum.

The operation never caused the slightest pain, the perforation always healed within twenty-four hours, and the relief gained by the evacuation of the fluid contents of the tympanum lasted, in each instance, for a month, at least, and sometimes longer. In only one instance could bubbles be seen in the tympanum before the membrana tympani was incised, viz., on the 19th February, 1876.

The case never presented, on any other occasion, the ordinary signs of mucus in the tympanum. In fact, the paracentesis, in the first instance, was performed solely on the strength of the subjective feelings of moving fluid in the drum-cavity.

This operation gave relief until March 28. On this occasion the membrana tympani showed a brownish-purple color. The hearing had become dull, and the ear felt "stopped up." No form of inflation relieved the symptoms. A *twelfth* perforation of the membrana tympani, at the same place, the lower posterior quadrant, gave vent to the usual kind of fluid, and effected a return of hearing. After the perforation and inflation, the membrane became more of a normal bluish-pearl color.

April 8. There was a reaccumulation of fluid in the tympanic cavity. The patient felt at this time the movable drop of fluid in his ear. The *thirteenth* paracentesis was performed, followed by the escape of the same kind of fluid, and the usual relief to his hardness of hearing.

24*th.* A similar condition of the ear, the *fourteenth* paracentesis, and relief of symptoms.

May 17. A similar note, with a *fifteenth* paracentesis, and the same discharge and relief.

June 20. The same note, with a *sixteenth* operation.

Aug. 23. Similar note, with a *seventeenth* paracentesis. It should be stated that the patient was obliged to be out at night, and in all weathers, as policeman at the Centennial Grounds.

Oct. 23. Same notes, with the *eighteenth* paracentesis, in the same spot, lower posterior quadrant of the drum-head.

Dec. 27. A similar note, and the *nineteenth* paracentesis.

Feb. 6, 1877. A similar note, and the *twentieth* paracentesis. There were no pharyngeal nor nasal symptoms to account for the reaccumulation.

March 27. The same condition of the ear, and the *twenty-first* operation for relief was performed.

May 11. A similar note, and the *twenty-second* paracentesis was performed.

The patient was not seen for a long interval—not until January 25, 1878. He stated that for four months past, his ear had been growing duller or "filling up," as he said, and that the sensation of distention had at last become painful. The membrana tympani revealed symptoms in no way different from those usually seen when the patient had presented himself for operation. The hearing was very much reduced; the voice being heard only a foot. I performed paracentesis, the *twenty-third* time, at the lower posterior quadrant; the same kind of brownish, tea-colored transparent fluid escaped from the perforation thus made, and the relief to hearing was as great as ever—the voice being immediately heard normally. This shows that no organic change can have taken place in the conducting apparatus of the middle ear, though the origin of the fluid in the drum-cavity, remained yet obscure.

Feb. 25. Another "filling up" in the ear had occurred again, and a paracentesis, the *twenty-fourth*, gave the similar results of discharge and relief.

July 26. A similar note, and the *twenty-fifth* operation, with relief.

Nov. 29. A similar condition of the ear, and a *twenty-sixth* paracentesis, with the usual results.

June 5, 1879. An interval of six months elapsed. The patient came again with the ear "filled up." The *twenty-seventh* paracentesis was performed with the usual favorable results.

Sept. 26. Upon this occasion, bubbles were distinctly seen behind the lower half of the membrana tympani. These moved when the patient inflated by Valsalva's method, but his hearing was in no way relieved by the inflation. At this visit, the *twenty-eighth* paracentesis was performed; not so much fluid as usual escaped, but the hearing returned.

June 15, 1880. A similar note, the *twenty-ninth* operation, and the same results.

Sept. 3. A similar note, with the *thirtieth* paracentesis.

None of the operations have ever been more than simple punctures in the membrane, and have never given any pain.

Sept. 5, 1881. Only one recurrence of the symptoms, and only one paracentesis in this year. This made the *thirty-first* operation.

Nov. 6, 1882. The patient stated at this time that his left eye had become dimmed in vision, and that his left ear was again stopped up. Paracentesis, the *thirty-second*, in the lower hinder quadrant, failed to give relief, because, as I found out later, the fluid this time required for an exit a perforation in the upper posterior quadrant (see note of March 27, 1883). Upon this occasion, I sent him to Dr. Charles A. Oliver for ophthalmic examination, whose notes may be consulted for the results he obtained.

Dec. 14. The hearing was found to be three feet for isolated words. The ear felt stopped up, but the membrana tympani looked smooth and fairly normal in color. The *thirty-third* paracentesis was made, a rather opaque, yellowish fluid escaped, and the hearing thereafter was six feet for same tests as above named. The membrana tympani became very much retracted and thrown into rugæ, and bluish-white in color, as on March 14, 1875.

Jan. 21, 1883. Patient again felt his ear stopped up. He seemed rather feeble at this time. The *thirty-fourth* paracentesis was made, and a slightly opaque, yellowish, thin fluid escaped, after which the hearing became relatively normal.

30*th*. A similar condition of the ear again noted. The *thirty-fifth* paracentesis was performed, and a thin yellowish fluid escaped. The hearing was made better thereby, but it did not seem to reach the same high point after the operations as some years previous. The paracentesis left no scar on the membrane. The latter healed in a few hours.

March 27. Patient complained that his ear was again "filled up." No bubbles were seen behind membrane before paracentesis. The *thirty-sixth* operation was then performed. The membrane seemed tougher than usual. Valsalva's inflation forced out a little frothy, brownish fluid, as in previous instances. By this inflation, bubbles were seen moving in the upper and hinder quadrant, but they did not escape through the perforation in the lower posterior quadrant. A second paracentesis was then made in the upper posterior quadrant, and considerable pale, yellow, thin, transparent fluid escaped. Patient said his eye and ear felt better. Hearing for words before the operation, eight inches; after operation, five feet.

In the operation of November 6th, and in that of March 27th, the paracentesis in the lower posterior quadrant did not seem to be adequate for the perfect drainage of the tympanic cavity. Hence in the operation of March 27th, a second puncture was made in the upper posterior quadrant where the bubbles were seen, which could not escape from the first and lower opening, and more fluid escaped from this second upper opening than from the first and lower one.

May 1. The patient complained of a stuffed feeling in his ear, and for the *thirty-seventh* time, the membrana tympani was perforated at the lower posterior quarter; but not a drop of fluid escaped, nor could the patient inflate the drum-cavity by Valsalva's method.

3d. The patient still complained of the stuffed feeling in his ear, and he said he could not inflate by Valsalva's method. Paracentesis for the *thirty-eighth* time was performed, and a drop of grayish opaque fluid was forced out by Valsalva's method. The case seemed to be changing in type, appearing to be more like an ordinary case of hypertrophic catarrh of the drum-cavity.

On *June 6th*, the symptoms of deafness being the same, without any evidence of fluid in the drum-cavity, the catheter was used for inflating the left Eustachian tube, since the patient was unable to inflate as he once could by Valsalva's method; but this gave no relief to his deafness nor the sensation of fulness in the ear. The patient was evidently weaker; was dizzy when he stooped, and when he walked. The scar made by the perforation of May 3d was still very plainly visible, demonstrating the want of the quick reparative power always heretofore seen in this case.

Aug. 10. The hearing for voice was six inches, only in the left ear. Inflation by Politzer's method increased the hearing to several feet. The tuning-fork vibrating on the vertex was heard best in the right ear, and the voice in the left ear, when words were uttered close to it.

20th. The patient could again easily inflate his ears by Valsalva's method. His hearing was nearly relatively normal, *i. e.*, three or four feet for vocal sounds, and he had no further sensations of filling up of his ear with fluid, the occurrence of which he had learned to recognize. He was just as dizzy as ever, especially when he turned around suddenly. The direction of the turning made no difference; he would stagger toward either side. The scar of the last paracentesis was still plainly visible, as a red, scab-like line on the manubrium, near the short process, where it had moved from the lower posterior quadrant of the drum-membrane. The membrana tympani moved easily and plainly under Valsalva's inflation.

Dr. Chas. A. Oliver, who has made, in this man, extensive and skilful ophthalmological examinations, has come to the following conclusions, which tend to explain the vertigo and altered gait in this case:

"*A.* A chronic pachymeningtis, limited to the anterior two-thirds of the left base, involving a few of the nerve-sheaths at their foramina; causing subvaginal œdema, with consecutive neuritis and partial atrophy.

"*B.* A new growth, very chronic in its development and course, situated in any part of the brain not directly interfering with any motor or sensory nerve-structure. The neoplasm causing pressure in all directions, with accidental passage of arachnoidal fluid through a few of the weaker foramina into the outgoing nerve-sheaths; this serous exudation producing incomplete choking of the nerve, followed by inflammation and atrophic degeneration.

"*C.* Sclerosis of the posterior columns of the spinal cord; the disease having advanced as far as the beginning of the stage of full development, without complication or extension of morbid process."

The point the case just narrated illustrates is, the great probability that many a case of chronic deafness is only due to retained mucus in the cavity of the drum, the symptoms of which have not been, and cannot always be, clearly defined, for they may not be at all sharply expressed on the drum-head. It also shows that repeated paracentesis may be performed with great benefit.

Where this fluid came from, and what caused its constant recurrence, are not easily answered. The Eustachian tube was always pervious to Valsalvan inflation, and to the air of the catheter, Politzer's bag, etc.

The difficulty of diagnosticating the presence of fluid or even inspissated mucus in the tympanum, in such cases of chronic catarrh, depends on several causes. The chief obstacle is, of course, the more or less altered condition of the membrana tympani. This may be so uniformly thick as to prevent seeing the delicate outlines of bits of mucus or bubbles lying against its inner surface. If it is cicatrized at any point, the retained fluid will cause a bulging at the cicatrix almost invariably, especially after inflation; but, if the membrane is uniformly thick, the mucus cannot make it bulge at any one point. Recent accumulations are most likely to cause in general bulging of the membrana tympani, but chronic accumulations cause a retraction. In the latter instance, there is a vacuum of air in the drum-cavity. This is a very prominent symptom of chronic retention of fluid in the tympanum. If only one ear is affected, the examiner will be aided in his diagnosis by comparing the two ears. He will be guided by the difference in position between the two membranæ, and also by the color. The membrana behind which there is retained fluid will bulge more than its fellow, if the drum-cavity be full of recent exudation; less so, if the matter in the drum be an old and fluid accumulation. The color of the membrane is affected by the matter retained behind it. Instead of being bluish-steel in color, it becomes a tint of gray-amber in color. These are guiding-points in favor of paracentesis, even if bubbles in the fluid cannot be discerned behind the drum-head.

ELECTRICITY IN AURAL DISEASES.

In 1868, Dr. Rudolph Brenner, of St. Petersburg, published his renowned work on Electro-otiatrics. His book consisted of a series of investigations and observations respecting the operation of electric currents upon the organ of hearing, both in health and in disease. It was avowedly an endeavor to found a rational electro-otology.

For seventy years previous to this time, *i. e.*, from the time of Volta, and his zealous pupil Ritter, numerous experiments had been made to find out whether and how the auditory nerve reacted under electric stimulation; but, as Brenner says, this period closed without any definite knowledge on this point. In the historical sketch which precedes the account of Brenner's labors, the reader is informed that the first experiments were performed in 1800–1802 by Volta and Ritter; afterwards by Grapengiesser, who apparently was the first to produce sensation of sound by means of a simple current. From this time the entire subject remained untouched until Erman, in 1812, revived it. A long pause in this kind of work then ensued, until once more the subject was resumed by R. Wagner, in 1843, who stated that it was extremely difficult to produce sound-sensations in the ear by means of galvanism. Then followed the testimonies of E. H. Weber, 1846, E. Harless, 1853, and Longet, 1850, that sound-sensations could be produced in the ear by means of the electric current.

Schiff, 1858, Ludwig, 1858, and Fick, 1860, appear to be in doubt whether the nerve is really electrically excited in those cases in which sound-sensation appears to be produced; they incline to the view that it is due to purely mechanical excitation of the sound-conducting parts, as did E. H. Weber.

Dr. Brenner has usually employed in his experiments a zinc-copper battery, but he has also used zinc-carbon batteries. The first, especially the Siemen's modification of Daniel's battery, is preferable on account of its more constant stream and slow exhaustion. Twenty of the above-named cells will be sufficient for all purposes connected with the application of electricity to the ear.

Mode of Application of Electricity to the Organ of Hearing; Instruments employed.—The electrodes are connected to the ear by means of wires inclosed in rubber tubing. They should be from six to ten feet long, in order to allow of perfect freedom in movement, change of position, and varying distances between battery and patient. The electrodes may vary in pattern: small ball-shaped ones, covered with thick muslin, which can be wet with salt and water, are preferable when the electrode is to be simply placed in the meatus, unfilled with water. The form of electrode for the ear, used chiefly by Brenner, consists of an ordinary hard-rubber ear-funnel, to which is fastened copper wire extending down the long axis of the funnel. This form is to be used in the auditory canal filled with tepid water.

The number of elements to be inserted into the current is decided by means of what is called a polarity chooser (Stromwähler), the current is turned by a polarity changer (Stromwender), and its rapidity, *i. e.*, intensity, is lessened by a rheostat or resister. Inserted into the current may be a magnetic needle, which will always give information to the surgeon, respecting the activity of the current. After ten years of most careful observation, Dr. Brenner has become convinced that the auditory nerve can be excited by the electric fluid, and he has announced the following formula for describing the phenomena which occur during such galvanic excitation.

Brenner's Normal Formula of the Reaction of the Auditory Nerve.—The signs used in this formula are: G (Geräusch, noise), to designate the acoustic sensation excited by the galvanic current; the degrees of intensity, by G′ and g; closing the current by S (Schliessung); duration of the current, D (Dauer); and the opening of the same by O (Oeffnung). The direction is indicated by the name of the electrode in the ear at each moment of separate excitation, *i. e.*, the kathode by Ka, and anode by A. Then the phenomena occurring by galvanic excitation of the auditory nerve may be expressed thus:

Ka S G′: means that a marked sensation of sound occurs at each closure of the current, while the organ of hearing is under the influence of the kathode and the anode is placed upon a spot of the body at a distance from the ear.

Ka D G >: means that a sound is heard, which rapidly diminishes and finally ceases, while the current runs in the same direction.

Ka O—: When the current is opened no sound sensation is perceived.

A S—: If, now, the current be turned, so that the organ of hearing come under the influence of the anode, there occurs no sensation of sound by closing the current.

A D—: Nor does such occur during the continuance of the current.

A O G: But by opening the current, sound sensation occurs, which corresponds qualitatively with that which was perceived when the current was closed while running in the opposite direction. But this sensation is much slighter and only of momentary duration.[1]

There may be several deviations from this normal formula in certain pathological conditions of the auditory nerve. Dr. Brenner gives the following:

1. Simple hyperæsthesia: An auditory nerve thus affected, reacts under electric currents very much weaker than those required to produce a corresponding excitation in the normal auditory nerve. Thus the duration (D) of the reaction during the moments Ka D and A O is much longer, and during a moderate current the Ka D-sensation does not terminate before the opening of the current.[2]

2. Hyperæsthesia with qualitative alteration of the formula: In this state the reaction of the auditory nerve under the electric excitation manifests not only an easy excitability, but also a change in its mode of occurrence. Thus, with Ka S, Ka D, and A O there is a subjective ringing, and with A S, A D, and Ka O there is hissing.[3]

3. Inversion of the formula for simple hyperæthesia: In some cases the disappearance of the normal formula in presence of the pathological, can be very striking. The former may be characterized by the lower notes of the scale, and distinguished from the pathological reactions by shortness of duration. With weak currents this condition does not manifest itself.

4. Hyperæsthesia of the auditory nerve with the parodoxical formula in the unarmed ear.

This form of hyperæsthesia is very curious and very frequent, and has been observed by Brenner only in old and deep disease of the ear.

This form is characterized by the circumstance that during the application of electricity to one ear, not only the auditory nerve of that side but also that of the other ear responds, but in an inverted manner, so that in the ear not under treatment the perceptions of sound occur at those moments of excitation, during which the nerve of the ear immediately under treatment is silent; the ear not treated reacts exactly as if it were under the influence of the other electrode.[4]

The observations and formula of Brenner have been fully verified by Erb,[1] Moos,[2] and Hagen,[3] in Germany, and by Blake and others in this country.

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[1] Brenner, Electro-Otiatrik, p. 91.

[2] Op. cit., p. 183.

[3] Op. cit., p. 195.

[4] Brenner, op. cit., p. 201.

Schwartze,[4] Shulz,[5] and Benedikt,[6] have been the principal opponents of the views of Brenner. The present status of the question may be said to be as follows: Brenner and his co-laborers believe that they have demonstrated that the subjective sound-sensations occurring during a galvanic examination of the ear, are produced by direct stimulation of the auditory nerve. The opponents above named admit the sensations, but believe that these sensations depend upon reflex irritation of the trigeminus and the sympathetic nerve.

A somewhat new field of therapeutic application of the constant electric current has been opened by Dr. Weber-Liel, of Berlin. This observer introduces the current through the Eustachian tube by means of a silver wire conveyed through a catheter.[7] By this method he claims to bring the muscular structures of the tube and perhaps those of the middle ear (tensor tympani and stapedius) under the direct influence of the galvanic current. It will be seen that in such an application of electricity, the direct irritation of the auditory nerve is left out of consideration. The treatment is really applied to the middle ear, and probably marks a new era in the use of electricity in some forms of aural disease, as, for example, in cases of atrophy, flaccidity, or degeneration of the muscles. In such cases perhaps the muscular structures of the middle ear derive a benefit from the gymnastic, as well as from the dynamic effect of the electric current.

It is claimed by Weber-Liel that this kind of intra-tubal electrization will relieve the symptoms of paralysis in the tubal muscles, cause the subjective noises to cease, and bring the hearing almost to the normal standard, if the treatment is begun before secondary changes have occurred in the tympanum, and if no other complication exists. He also states that after the tubal muscles have been thus galvanized, the air from the catheter can be forced into the tympanum more readily, without the aid of swallowing, the latter is more easily performed and inflation by Valsalva's method succeeds where before it failed, all of which he adduces as proof that the paralysis of the muscles concerned in these acts has disappeared, and that the disappearance is due to the use of electricity.[1]

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[1] W. Erb, Die galvanische Reaction des nervösen Gehörapparates, etc. Archiv f. Aug. und Ohrenheilk., Band i. S. 157, and Band ii. S. 1–51.

[2] Klinik der Ohrenkrankheiten, 1866, p. 332, and elsewhere.

[3] Electro-otiatrische Studien. Wiener Med. Wochenschrift, 1866.

[4] Archiv f. Ohrenh., Band 1.

[5] Sitzung der k. k. Gesellschaft d. Aertze, 2 July, 1865; also Wiener Med. Zeitung, 1865, No. 23.

[6] Wiener Med. Presse, 1870. Nos. 37, 39, 42, 43, 47, 48, 50, 51, and 52.

[7] Progressive Schwerhörigkeit, p. 36.

But the latter part of the proposition cannot be so easily admitted, since exactly the same improvement in these parts does occur after a careful catheterization, and the use of a bougie, the latter being passed up into and even past the isthmus tubæ.

Not only in recent but in chronic cases of catarrhal disease, and closure of the tube, in which neither by the catheter, Valsalva's method, nor by the act of swallowing, the tube could be opened, a bougie passed into the tube on two or three successive days, has appeared to stimulate the tubal muscles to proper action, without the aid of electricity.

To illustrate this, let me bring forward the following case: Mr. T., 40 years old, of Maine, consulted me with his physician, for deafness in the right ear, following a copious and chronic nasopharyngeal catarrh. The active catarrhal symptoms had been checked, and the mucous membrane of the nares and pharynx was abnormally dry. The right membrane was thin; promontory and incudo-stapedial joint visible through the membrane; lustre good. Great tinnitus; hearing for watch $\frac{0}{60}$ in. At the first visit, air could not be forced into the tympanum by the catheter nor by the Politzer bag. A silver catheter was then introduced, and through it one of Weber-Liel's admirable tympanic catheters (delicate flexible bougie-catheters of gummed silk) was pushed through the silver instrument and into the tympanum. This produced an immediate though slight improvement in hearing; the operation was repeated on three consecutive days, and by the fifth day after the first operation the patient volunteered the statement that "his ear opened whenever he swallowed, a sensation he had not noticed for nearly a year." Air could now be forced into the tympanum both by the catheter and Politzer's method. The hearing rose to $\frac{3\text{ in.}}{60\text{ in.}}$ for the watch, but the tinnitus was not materially altered. The patient, being obliged to leave the city, passed from under my treatment.

The case is quoted chiefly to prove that the signs of muscular paralysis may be made to disappear without the aid of electricity.

Since in this case, and in many similar ones, the physical manipulation of the diseased parts is almost identical with that adopted by Weber-Liel in his intra-tubal electrization, excepting that the latter factor, the passage of the electric current, is left out, and since the result is about the same in both instances, it would really seem that the benefit in such cases depends upon a thorough opening of an occluded Eustachian tube, and the consequent restoration of the tympanum to a proper degree of ventilation, and *not upon electricity*.

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[1] Op. cit., p. 165.

Dr. Hitzig[1] prefers the so-called external application of electricity for therapeutical purposes. But he thinks that the electrization of the muscles in the tympanum, by means of the electrode (wire) introduced into the Eustachian tube, may in the future be shown to be of value, but for the direct excitation of the acoustic nerve this method has but a limited supplemental worth.

CHAPTER IV.

DISEASES OF THE MIDDLE EAR (*Continued*).

It is proposed to devote this chapter to the consideration of several rare and interesting pathological processes, in the middle ear. Some of these about to be described have been observed in close connection with catarrhal processes in the tympanum, and some of them may have had their origin in such a process in the tympanic cavity. They are certainly full of interest to the aurist, and not without interest to the general practitioner. As these diseases are rare, and some of them malignant, it must be accepted beforehand that the treatment is an open question in some, and unsatisfactory in others. One of the rarest and most interesting is that first described.

Objective Snapping Noises in the Ear.—Sometimes there occurs a snapping or cracking noise in the ear, which is audible not only to the sufferer but to others. This noise has been likened to the snapping of the finger-nails, or to the sudden drawing apart of the finger-ends when slightly moistened with saliva or a tenacious fluid. The first simile is the more striking. Some persons possess the power of voluntarily producing such a sound in the ear. It is known that Fabricius ab Aquapendente and Johannes Muller,[2] were able to produce such a sound; the former only on both sides at the same time, but the latter in either ear according to his desire. It was ascribed by him to a voluntary contraction of the tensor tympani muscle. Muller[1] was disposed to regard this voluntary power as not uncommon, and mentions the fact that Meyer had known a gentleman who possessed it.

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[1] Bemerkungen über die Aufgaben der "Electro-otiatrik" und den Weg zu deren Lösung. E. Hitzig. A. f. O., N. F., Bd. 2, S. 70.

[2] Manual of Physiology, London, 1838–1842. Translated by Wm. Baly, M.D., p. 1262, vol. ii.

Lucae[2] has observed this power to voluntarily produce a snapping noise in the ear, or to contract the tensor tympani, as he believes, in three friends, all of them scientific men. Politzer[3] observed both the voluntary and involuntary production of this snapping noise, in the ear of a young physician, and Schwartze[4] alludes to the voluntary ability to make this peculiar noise, as do Schrapinger,[5] Delstanche, fils,[6] S. M. Burnett,[7] and Brenner.[8] I have observed on several occasions this power in certain individuals, all of them affected with an aural disease. Two of them were physicians, and with the noise, which was rather a creaking or a whizzing than a snapping, visible motion occurred in the membrana tympani. In one it was heard on both sides, and cicatrices in the membranes were seen to move most distinctly, and also seemed to contribute to the noise by a kind of crackling sound. In the second case the noise was not very loud, but the membrana tympani moved visibly. The third instance was in a patient, a young man, twenty-three years old. The hearing was normal in the ear in which the noise was made. Instances of the *involuntary* occurrence of a snapping sound in and from the ear have been observed by Schwartze,[9] Boeck,[10] Politzer,[11] Leudet,[12] Küpper,[13] and myself.[14]

Since the publication of the first edition of this treatise, Holmes,[15] of Chicago, has reported the occurrence of involuntary, objective snapping sounds in both ears of a young woman, eighteen years old, accompanied by involuntary spasms of the pharyngeal muscles, forty times a minute. Bürkner[16] reports the occurrence of this phenomenon in the ear of a man, twenty-seven years old, induced by a blow. Chas. A. Todd[17] reports its occurrence in the ear of a man, the noises being accompanied by simultaneous spasm in the velum and sterno-cleido-mastoid muscle; and R. C. Brandeis[1] gives an account of observing this peculiar noise in both ears of a girl, twelve years old. In this case there were synchronous spasms in the soft palate, uvula, accompanied by simultaneous movements in the membrana tympani. The muscular contractions also extended to the digastric muscles on both sides, as well as to the mylo-hyoid and thyrohyoid muscles, but no movements in the larynx, either as a whole or a part.

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[1] Manual of Physiology, London, 1838–1842. Translated by Wm. Baly, M.D., p. 1262, vol. ii.

[2] Archiv f. Ohrenheilk., Bd. iii. S. 201, 1867.

[3] Ibid., Bd. iv. S. 19–29, 1868.

[4] Ibid., Bd. vi. S. 228, 1870.

[5] Transactions of the Austrian Acad. of Sciences, vol. 62, sec. 2, 1870.

[6] Etude sur le Bourdonnement de l'Oreille; Paris et Bruxelles, 1872, p. 47.

[7] Archives of Otology, vol. viii. p. 357, 1879.

[8] Monatsschrift f. Ohrenh., No. 10, 1879.

[9] Archiv f. Ohrenheilkunde, Bd. ii. S. 5, 1867; also Ibid., Bd. vi. S. 228, 1870.

[10] Ibid., Bd. ii. S. 203, 1867.

[11] Ibid., Bd. iv. S. 19–29, 1868; also Wiener Med. Presse, 1871.

[12] Gazette Médicale de Paris, Nos. 32, 35, 1869; Comptes rendus de l'Academie de Science de Paris, May 10, 1869.

[13] Archiv für Ohrenheilkunde, Bd. i. N F., 1873, S. 296.

[14] Philadelphia Medical Times, Nos. 172 and 181, 1875.

[15] Chicago Med. Journal, May, 1879.

[16] Archiv f. Ohrenh., Bd. xv. S. 219, 1879.

[17] St. Louis Courier of Med., July, 1880.

H. N. Spencer[2] and Wagenhäuser[3] have reported the occurence of an objective aneurismal-like bruit, emanating from the ear, the first in a man, the second in a woman. It was undoubtedly vascular in its origin in both instances.

Murmurs of systolic origin are occasionally heard, both objectively and subjectively. These have been described[4] as objective and subjective murmurs, and are classed under brain-murmurs. They may be independent of aural disease, and usually occur in the young. They are probably due to the fact that the internal carotid artery develops more rapidly than the osseous canal in the petrous bone, through which it passes in its way to the brain. The stenosis thus brought about in the blood-vessel, induces, by the pressure of the blood from behind, a gradual and sufficient enlargement in the canal. The systolic murmur heard in such cases is purely physiological.

An objective whizzing sound may come from the ear during mastication, as observed by Moos, but this is not to be classed with the distinct, involuntary, spasmodic, snapping sounds in the ear, which may be heard objectively in some rare instances.

There are, however, several cases on record in which a peculiar objective noise in the ear has occurred without any act of volition on the part of the patients. The noise is often very frequent, loud, and distressing in its occurrence, and presents interesting and varied features enough to warrant it a separate mention here.

Since the time of Müller's observations on himself, this peculiar snapping noise in the ear has been variously ascribed to either voluntary or involuntary contraction of the tensor tympani, to clonic spasm in the stapedius muscle, in a single case, by Wreden, or to spasm in the palatal muscles whereby the anterior wall of the mouth of the Eustachian tube is suddenly drawn away from the posterior wall and the noise is thus produced. The latter view is that of Politzer and Lushka and is now received as sufficiently explanatory of the majority of the cases which have been observed. According to this theory the noise is really produced in the nasopharynx, but is conveyed to the ear of the subject through the Eustachian tube. The ear of an observer also perceives the noise as coming from the ear of the person in whom the peculiar sound originates. The noise is also heard equally well at the nostril of the patient in many cases. The case of spasm of the stapedius muscle described by Wreden is, so far as I know, unique, unless a very low and gentle tapping sound which I once heard in the ear of a patient, by placing my ear close to his, was to be explained by an involuntary twitching of the stapedius. There was nothing but its faintness that led me to this conclusion. There was no dizziness nor deafness. The cases of Leudet and Delstanche are considered by them as examples of an objective snapping noise in the ear, due to spasm of the tensor tympani muscle. That of the former was involuntary, while that of the latter was voluntary. But the account of Leudet is evidently one of this peculiar noise produced by the spasmodic opening of the mouth of the Eustachian tube; as indeed was that of Delstanche, for in both there is history of simultaneous movement in the palate.

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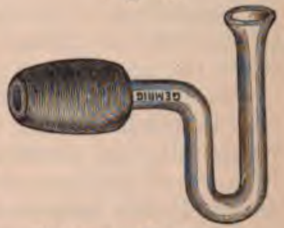
[1] Archives of Otol., vol. xii., 1883, p. 14.
[2] Amer. Journal Otol , vol. iii., 1881.
[3] Archiv f. Ohrenh., Bd. xix. S. 62, 1882.
[4] J. O. Green, American Otological Society, 1878.

The following is a short account of the above-named curious affection, occurring in a Japanese lad eighteen years old. The patient came under my care for treatment of a chronic suppurative inflammation of the left middle ear, with perforation of the membrana tympani, the result of acute inflammation incurred in July, 1874, by diving in cold salt water. The nasopharynx and the pharynx were catarrhal, for which he was treated by applications to the pharynx and nares. The patient complained only of the left ear. He did not draw my attention to the right ear, affected by the spasm about to be described, but while inspecting the right ear for purposes of comparison, I heard distinctly a noise resembling the snapping of the finger-nails, emanating from it. The snapping was most audible when the ear of the listener was placed close to the right ear of the patient, but it could be distinctly heard ten feet from the ear from which it came. It was also heard very distinctly when the ear was placed near the right nostril of the patient. It was not, however, audible in the left ear of the patient, neither by placing my ear on his ear, nor by the use of the auscultation-tube. Inspection revealed a thickened and reddened condition of the right membrana tympani; and the patient stated that he had had, some years previous, discharges from the right ear, and it was found that the hearing was defective in it.

The snapping sounds began in it in the previous summer, one week after the acute inflammation in the left ear. At the first examination, by simple inspection, no motion was detected in the membrana tympani at each snapping, but in the course of a month, the thickening of the drum-head becoming less, a very slight retraction of the drum-head at its antero-superior quadrant was seen. Before any motion in the drum-head was observed by simple inspection, to occur with each of these peculiar objective noises, I placed a small glass manometer devised by Politzer, with its capillary calibre, one millimetre in diameter, filled with colored water, into the meatus of the right ear, also filled with water, the two columns of fluid being hermetically joined by an India-rubber stopper on the manometer. The column of water thus brought into contact with the membrana tympani, showed a negative fluctuation of one-half millimetre at each snapping sound, thus demonstrating a retraction of the membrana tympani too small to be seen at that time by inspection, but later, apparent upon close and attentive inspection. The drum-head moved readily under the Siegle pneumatic speculum.

Fig. 91.



POLITZER'S MANOMETER.

The examination of the fauces revealed an elevation and retraction of the velum palati, chiefly on the right side, with each snapping sound in the ear and each manometric depression. The negative fluctuation—*i. e.*, depression in the manometric column—amounting to one-half millimetre, occurring at each objective sound in the ear, was entirely distinct from a very slight positive oscillation in the same column at each cardiac impulse. The latter could not always be discerned.

Deglutition, respiration, and speech exercised a marked influence over the spasmodic condition already described. The patient stated that deglutition and rapid respiration increased the frequency of the snapping noise in the ear, but that when he held his breath, the spasms in the velum palati and the snapping noise in the ear, ceased entirely, to begin again with renewed respiratory acts. I found, indeed, that so long as the patient held his breath neither he nor I could hear any snapping, nor could I detect any spasmodic movement of the velum; but they all recurred as soon as the patient resumed his breathing. During ordinary respiration I counted twenty spasms in a minute, which appeared to be the average number; but with a voluntarily increased number of respirations, the number of snappings and spasms of the velum rose to thirty in a minute. During continued speech no snappings occurred.

These peculiar snappings were not in regular succession, nor synchronous with the respirations. Two or three snappings usually occurred in quick succession, were followed by a pause, then there were several more, thus completing twenty in a minute. These noises interfered so much with the hearing in the ear in which they occurred, that the patient, when specially desirous to increase his hearing, held his breath, which, as already stated, would control the spasms. It was found by testing with a watch, audible normally sixty inches, that the hearing was indeed influenced by the spasms and their temporary cessation as the patient had stated; for the watch, audible to him only on contact during the spasms, was heard two inches when the noises were arrested by holding his breath.

Tuning-forks held before the ear, appeared to the patient to rise in pitch at each spasm. The rise in the note was well imitated by the patient. This altered pitch was to be expected, because at each spasm the drum-head was retracted, and rendered, by this increased tension, more sensitive to high than to low notes, and hence the ear perceived the higher, to the exclusion of the lower partial tones of the tuning-forks.

The snapping sounds, but not the spasmodic elevations in the velum, could be arrested in two other ways. By throwing the patient's head back as far as he could get it, although the spasms in the velum palati went on with the usual intervals, the objective noises in the ear were arrested. I could also stop the noise by pressing my finger firmly against the velum, and pushing it upward towards the pharyngeal opening of the right Eustachian tube. Although a powerful twitching, with the usual intervals of repose of the muscular structures thus pressed upon, could be felt, all snapping noises ceased. Pressure upon the left half of the velum palati and mediately upon the pharyngeal opening of the left Eustachian tube revealed no twitching in that region, nor did it influence in any way the spasms and noises on the opposite side of the pharynx and in the right ear.

As the patient expressed no desire for relief from this objective noise in the ear, seventy-two days went by, with a number of opportunities of observing all the phenomena just detailed. On the seventy-second day after I had first heard the snappings from the ear, the patient informed me that, within a few days, a perforation had occurred in the drum-head of the ear from which the noises emanated, and that the latter had greatly decreased in loudness and frequency. Inspection then revealed, indeed, a perfectly well-defined dry perforation in the antero-superior quadrant of the membrana tympani, where previously the slight but spasmodic indrawing of the membrane had been observed; but there was no explanation of the perforation so far as could then be discerned, nor could the patient give any solution of its occurrence. In a few days, the snappings, which had become very infrequent and nearly inaudible, *ceased entirely*. Although a little mucous discharge ensued in about a week after the perforation, probably from exposure of the mucous lining of the tympanic cavity to the winter atmosphere, it was easily checked, and the membrana tympani closed. Since then there has been *no return of the snapping noises, nor any spasmodic motion in the velum palati, Eustachian tube, middle ear, nor membrana tympani.* The young gentleman remained under observation until his return to Japan in the autumn of 1876.

Recently I have observed two other cases of objective aural noises, both of which were evidently connected with catarrhal disease in the nares and nasopharynx.

The first case was that of a young physician, twenty-eight years old, who consulted me, on October 5, 1883. He stated that for twenty months he had felt a "clicking" in his left ear, produced by both objective and subjective sounds: as, for example, the clicking of a card in the fingers, or the blowing of a shrill toy whistle near his ear, or by his own coughing, speaking, or singing. It was found that when he said m, n, or o, rather loudly but with no other vowel sound, this clicking in his ear was produced. I thought I could detect a slight change in the pyramid of light, *i. e.*, a slight motion of the membrana tympani, when he produced the "clicking" in his ear by uttering these consonant and the vowel sounds. I also faintly heard, by means of the auscultation-tube, the "clicking" in his ear, when he produced it as described above.

There was no difference in the sound, when induced by subjective or objective causes; it was more likely to be produced at night or the end of the day when fatigued, than in the early part of the day. Up to this time it had never occurred automatically, *i. e.*, without an objective or a subjecto-objective excitant. Subsequently, when the patient was run down by the winter's work, this "clicking sound" did occur automatically when he was entirely quiet.

The membrana tympani displayed a good lustre and the pyramid of light was fair; the membrana was retracted and the incus was visible. The membrana moved fairly under the pneumatic speculum. The right membrana manifested an identical condition. The Eustachian tubes were entirely pervious to inflations; the anterior and posterior nares were hypertrophic, the left markedly more so than the right; the pharynx was red, and manifested tobacco-smokers' pharyngitis. The patient had smoked cigarettes to excess, but had not done so recently.

There was at no time any discernible muscular spasm in any part of the pharynx nor velum palati, nor was the patient conscious of any spasmodic motion or twitching in any part of the nasopharyngo-aural tract.

Treatment.—The anterior, hypertrophied portions of both inferior turbinated bones were touched several times with Lugol's solution of iodine. Upon one occasion this mixture was pushed along the left inferior turbinated bone to the posterior pharyngeal wall. This caused pain and brought on an attack of the "clicking" in the left ear. The pain and the "clicking" were quickly allayed, however, by spraying the nostrils with fluid cosmoline (Petroleol). In a short time, *i. e.*, after four or five applications of the iodine to the inferior turbinated bone, and the use of the cosmoline spray, the hypertrophy became much less, and the noise in the ear occurred less readily and not so frequently. The patient then dropped all treatment until last spring, when the "clicking" became very annoying, occurring easily when the patient was exposed to noises, or when he sang, talked, or whistled. Finally the noise occurred automatically, even when the patient and his surroundings were perfectly quiet. The patient was somewhat debilitated, and about this time, after running up stairs one evening after supper, fainted upon reaching his room.

The nasal hypertrophies, both anterior and posterior, especially on the left side, seemed larger, and the nasal catarrh generally worse. He was advised to undergo nasal treatment at the hands of Dr. Seiler. The latter applied iodine and glycerine, equal parts, to the hypertrophies, sprayed the nares with Dobell's solution, and once scarified the hypertrophied tissues at the back of the septum on the left side, by means of the galvanic wire-cautery. This treatment produced very good results, the "clicking" practically ceased to annoy, as it occurred very rarely, and only very faintly. The improvement has been maintained to the present time.

Etiology.—There was in this case an undoubted spasmodic action in muscular tissue near the Eustachian tube, but entirely invisible to the examiner and not felt by the patient. I am disposed to locate the muscular spasm, in this case, in the upper fibres of the superior constrictor of the pharynx. This muscle arises from the lower third of the margin of the internal pterygoid plate, and its hamular process, from the contiguous portion of the palate bone and the reflected tendons of the tensor palati muscle, from the pterygo-maxillary ligament, from the alveolar process above the posterior extremity of the mylo-hyoid ridge, and by a few fibres from the side of the tongue in connection with the genio-hyo-glossus. Its superior fibres of insertion arch beneath the levator palati and the Eustachian tube.

The mucous membrane of this muscular tract was, as has been stated, markedly catarrhal, the inferior turbinated bones and the nares were hypertrophied, and the fauces were affected by smokers' pharyngitis. In these conditions in the mucous membrane, there is found sufficient cause of irritation of the sensitive nerves in these parts, this irritation is reflected to the underlying muscular structures through motor nerves, and there ensue spasmodic twitchings near the Eustachian tube which are perceived as subjective and objective noises.

That the origin of these "clickings" lay in the catarrhal condition of the upper pharynx and the nares is fully shown by the cessation of the noises upon the amelioration of the catarrhal symptoms.

The easy excitation of the spasms by talking, is explained by the fact that a few fibres of origin of the superior constrictor of the pharynx arise from the genio-hyo-glossus, and hence lingual motions would tend to excite the aforesaid sounds in the ear. It may also depend upon the motions of the jaw, as the constrictor has a partial origin from the posterior part of the alveolar process, and upon the movements of the buccinator, which has a common origin with the superior constrictor of the pharynx, in the pterygo-maxillary ligament. The annoying audibility of these muscular spasms is due to the insertion of the superior constrictor near the Eustachian tube.

Another case of objective snapping noises in the ear came under my observation within a short time, and is now under treatment.

Miss McG., aged twenty years, stated on June 2, 1884, that about six months previous she had first noticed a clicking sound in her right ear, and that her family noticed that they too could hear it. She is not disturbed by the noise at night, though it appears to be almost ceaseless. Its occurrence is paroxysmal, with short intervals. It is heard objectively quite as well—perhaps better—at the nostrils than at the meatus of the right ear. It is very well heard at the latter point by means of the ear-trumpet. The number of "clicks" is about eighteen or twenty per minute. With each clicking sound the lower maxilla is both felt and seen to move, chiefly towards the right side; the latter symptom is very annoying to the patient. A manometric column, attached to the right ear, rises and falls with each "click," due, very probably, however, to the motion of the lower maxilla and not to movements in the membrana tympani. The patient stated that she had of late begun to hear the noise in the left ear. Objectively, it is not very pronounced on this side; it can be heard however at this point. Pressure upon the muscles over the carotid on the right side, behind the angle of the jaw, arrests the motion of the latter and the objective noise. Opening the mouth very widely stops the noise almost entirely, only a faint "click" being heard now and then.

The patient is a pale blonde, somewhat neurasthenic; the right membrana tympani is opaque and retracted, and on this side the hearing is reduced to a few inches. The nares, nasopharynx, and fauces are catarrhal, and she often feels the dropping of mucus from her nasopharynx into the throat. Her spirits are not depressed by these peculiar aural phenomena, and she sleeps well. The motion of the lower maxilla, observed in this case in connection with each clicking sound, is due to a clonic spasm of the pterygoid muscles of both sides, but chiefly of the left side, as denoted in the greater tendency of the maxilla to move towards the opposite side, *i. e.*, towards the right, since when the external pterygoid muscle of one side acts either alone, or chiefly, the corresponding side of the jaw remains fixed, and the symphysis deviates to the opposite side.

The distinct, objective audibility of the spasms at the nares and auditory meatus, is due to the fact that the internal pterygoid arises from the pterygoid fossa, its fibres being attached to the inner surface of the external pterygoid plate, and to the grooved surface of the tuberosity of the palate bone. Its internal surface is in close relation to the tensor palati, while the external pterygoid arises from the pterygoid ridge on the wing of the sphenoid, and the portion of the bone included between it and the base of the pterygoid process, from the outer surface of the external pterygoid plate, and from the tuberosity of the palate and superior maxillary bones. Hence any vibrations occurring in the muscular structures near their points of origin, would be easily communicated by the Eustachian tube to the tympanic cavity and the external ear, and also directly through the nares to the external air. So that a snapping sound occurring in the region of these muscles would be at once a subjective and an objective noise, in and from the nasopharynx and ear. These sounds may have been augmented by a simultaneous spasm in the fibres of the superior constrictor of the pharynx, which has a small tract of insertion on the inferior maxilla, above the inner end of the mylo-hyoid ridge.

The spasms in the muscles in this case are to be accounted for, as in the previous instance, by the catarrhal irritation conveyed to the sensitive nerves of the mucous membrane in the vicinity of the muscles affected. The irritation is thus conveyed to the motor nerves of the muscles in the catarrhal tract, and the latter, in an endeavor to eject the irritant, are thrown into a series of clonic spasms.

Simultaneous Spasm in the Soft Palate.—In the vast majority of all the cases on record, this noise, whether voluntary or not, has been accompanied by a spasmodic elevation and retraction of the soft palate, and sometimes of other muscles of deglutition.

In the case observed by Küpper, there was, in addition to the movements in the velum, a simultaneous elevation of the larynx, the floor of the mouth, and the root of the tongue.

Simultaneous movements, *i. e.*, retractions of the membrana tympani, have been observed less frequently than the above-named motions in the velum. The indrawing of the membrane, when observed, has not always been at the same spot. It has varied from being at the point of the manubrium, to being at various other portions of the membrane. This would seem to militate against the theory that the noise, and consequently the retraction of the drum-head, is due to spasm of the tensor tympani muscle. For were it due to the latter, the indrawing of the membrane would be likely to occur in a line with the handle of the malleus, and not in one of the quadrants of the membrane, at some distance from the malleus, as it did in the case I have observed.

Simultaneous Twitchings Elsewhere.—In some instances the involuntary objective noise in the ear has been accompanied by simultaneous twitchings of the muscles of the brow, nose, and face, as in Küpper's case, which was ambilateral, or with simultaneous spasms of the mylo-hyoid muscle, of the anterior belly of the digastric, of the pterygoids, and in the brow on the same side, as was noted by Leudet, Todd, Brandeis, and myself. In the case by Brandeis there was neuralgia in the brow and amyosthenia of the fingers, on the side corresponding with the ear in which the noise was heard.

The age of those thus affected varies from five to fifty years, as shown in the cases reported by Schwartze. Of all those alluded to here in whom such an objective aural noise, either voluntary or involuntary, has been observed, six were females; four of whom were adults, the cases of Moos, Leudet, Holmes, and myself; while two were little girls, five and twelve years old, respectively, one observed by Schwartze and the other by Brandeis.

Involuntary objective noises in the ear, and the attendant symptoms already described, rarely occur on more than one side at a time; in six instances, however, they were observed to be in both ears, twice by Schwartze, once by Küpper, Holmes, Brandeis, and myself.

The mode of the occurrence of the involuntary snappings in the ear varies greatly. It may be too rapid to be counted (Schwartze), or isochronous with the pulse, and so loud as to waken the patient at night (Boeck), or it may resemble the ticking of a watch, with pauses (Schwartze). In the case observed by Leudet, the noises occurred in pairs, the one being a "kind of echo" of the other, and in the case cited by Küpper, they occurred irregularly, and as often as 140 times in a minute.

The state of the hearing in an ear thus affected varies with the cases, being in some normal; in others, noises occur in an ear already somewhat hard of hearing, while in some the hearing is momentarily affected, apparently by the altered tension which ensues in the tympanum, with each spasmodic occurrence of the noise.

Causes.—The causes of the occurrence of involuntary objective noises in the ear, have been sought for in several ways, as in neuralgia of the superior maxillary branch of the fifth pair, with tic of the seventh, and of the branch which the inferior maxillary sends to the tensor tympani by means of the otic ganglion (Leudet), or in a reflex spasm, conveyed from the sensory nerves of the diseased mucous membrane to the corresponding motor nerves, in cases connected with catarrh of the pharynx (Küpper). As an analogue to this peculiar affection of the ear, Dr. Küpper cites spasms of the orbicularis palpebrarum in connection with diseases of the conjunctiva. As shown in the cases I have observed and narrated above, the clonic spasms causing these objective noises are the reflex result of the irritation from the catarrhal inflammation of the mucous membrane in the nasopharynx. Doubtless the retraction of the membrana tympani in some instances of objective noise in the ear, may have been due to a contraction of the tensor tympani muscle, but in the case of the Japanese, already given, the retraction of the drum-head was due, most probably, to the formation of a vacuum in the tympanum, produced by the sudden drawing apart of the walls of the faucial mouth of the Eustachian tube. This I consider all the more probable since the retraction ceased, as did the spasm of the velum and the noise, as soon as the membrana tympani ruptured.

Treatment.—The whole number of these cases is comparatively small, and the individual experience in regard to them limited, so that our knowledge respecting the therapeutics of this variety of aural disease has been very meagre. So far as we can glean an opinion from what has been written by others concerning the treatment of these cases of clonic spasms, the induced current has effected the only apparent relief and cure (Schwartze, Politzer, and Boeck). This was tried without any good effect in the case of the Japanese, narrated as occurring in my own experience. Since spontaneous perforation of the membrana tympani in this case was soon followed by entire cessation of the clonic spasm in the velum, and elsewhere in the ear, and of the peculiar noises in the ear, I would recommend artificial perforation in any similar case, if speedy relief from the symptoms should be urgently required, or if they should not yield to treatment of the catarrh of the nasopharynx which so evidently underlies them as the true cause. The treatment the author has found beneficial in these spasms is set forth in the account given above of the cases he has observed. It must be directed to the inflamed nares and nasopharynx.

Extravasation of Blood into the Tympanum in Bright's Disease of the Kidneys.—An extravasation of blood into the tympanum in Bright's disease has been observed by Schwartze,[1] Buck,[2] P. McBride,[3] Raynaud,[4] and others. It has likewise been observed[5] that deafness is a symptom of Bright's disease not directly traceable to uræmia, and that pain and suppuration may occur in the later stages of this malady.[6] In the latter instance the tympanic disease may originate in an extravasation of blood into the drum-cavity.

It is not difficult to comprehend how, in the atheromatous and weakened condition of the vascular system in this form of renal disease, an extravasation may occur in the ear as it does in the eye and elsewhere. However, evidences in favor of either frequent or well-marked aural lesions, dependent upon renal diseases, are extremely meagre. Those lesions in the ear, which have been found in connection with Bright's disease and diabetes mellitus, and which may have been dependent upon the dyscrasia induced by these renal disorders, are in the form of sero-sanguinolent and hemorrhagic effusions into the drum-cavity. But the latter must not be mistaken for a sthenic form of otitis media hemorrhagica. From the serous nature of the membranous structures of the labyrinth, organic changes might reasonably be expected in that part of the ear in Bright's disease, but positive proof of the occurrence of such lesions, based on ante- and post-mortem history, is wanting.

Otitis Media Hemorrhagica.—Some observers claim to have detected a sthenic form of hemorrhagic otitis media. Its occurrence is certainly very rare. It has been observed by Roosa, Mathewson, Hackley, and O. D. Pomeroy. It is an acute and painful process, terminating in perforation of the membrana tympani and the escape of blood, but none of the ordinary results of inflammation. The pain is relieved by the escape of blood from the drum-cavity.

Tubercular Disease of the Ear.—Dr. Schütz[7] has made a study of tuberculosis of the inner and middle ear, with special reference to the etiology of this process and the manner of its further dissemination throughout the body. His investigations show that the disease is usually ushered in by a catarrh of the pharynx, accompanied by a pulpy swelling and subsequent cheesy degeneration of the neighboring lymphatic glands (lymphatic catarrh), and finally passes into the tympanic cavity through the Eustachian tube. The disease then attacks the bony tissue of the pars tympanica, which soon passes into a state of proliferation, and in the inflamed and swollen tissue the first small gray tuberculous nodules make their appearance (tuberculous osteomyelitis of the pars tympanica). At the same time small miliary nodules arise in the inflamed mucous lining of the cavum tympani. The tuberculous new formations finally fill completely the drum-cavity, dislocating the auditory ossicles, which become necrosed. The entire pars tympanica is changed into new growth, and the disease advances in a peculiar manner along the tracts of the nerves which touch the tympanic cavity.

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[1] Archiv f. Ohrenheilkunde, Bd. iv. S. 12.

[2] Diagnosis and Treatment of Diseases of the Ear, 1880, p. 164.

[3] Edinburgh Med. Journal, February and March, 1882.

[4] Annales des Maladies de l'Oreille, March, 1881.

[5] G. M. Smith, Transact. N. Y. Academy of Medicine, vol. iii.

[6] Roosa, op. cit., p. 257.

[7] Die Tuberculose des inneren und mittleren Ohrs beim Schweine nebst, etc. Virchow's Archiv, lxvi. p. 93. See review by Steudener, A. f. O., Bd. ix. S. 130–132.

At an early period the tuberculous growth penetrates into the Fallopian canal and attacks the facial nerve, which by this deposit of tuberculous nodules in its interstitial connective tissue, is entirely separated into its individual fasciculi. Finally the internal ear is attacked, the semicircular canals and the cochlea are filled with an exuberant tuberculous mass, which by the way of the aquæductus vestibuli et cochleæ passes into the cranial cavity. In the same manner the process advances in the connective tissue of the acoustic nerve and into the internal auditory canal, from which at last a tumor as large as a walnut may extend into the cavity of the cranium. It is worthy of remark that the dura mater is never invaded by the new growth; it is only pushed ahead of it towards the brain.

From the tympanic cavity the new growth, after it has embraced the membrana tympani, passes into the external auditory canal and extends as a nodulated polypoid excrescence over the sulcus tympanicus and outward beyond it.

At a later period, caseous as well as fibrous and calcareous transformation, takes place in the morbid growth. Secondarily, tuberculous processes may occur in any other of the organs of the body.

Desquamative Inflammation of the Middle Ear; So-called Cholesteatoma of the Petrous Bone.—Dr. Wendt has given a new explanation of the greatly discussed question concerning the true nature of the so-called cholesteatoma of the petrous bone. He believes that in these cases there is present a special kind of inflammation which he terms desquamative. This disease is regarded as a collection of epithelium which is thrown off by the mucous membrane of the middle ear, in altered form and increased quantity, and which, finding no way of escape, is accumulated in the cavities of the middle ear, until it gradually fills them.

Eleven cases of this disease were observed in the living, one of which was examined *post mortem*. In every case the collections were composed of cells resembling scales of epidermis. The cells were arranged in lamellæ, through which were various, but never large, quantities of oil and cholestearin. In six instances the point of origin of these masses was undoubtedly the tympanum. In the other cases, simply their presence but not their origin in the tympanum could be shown.

Dr. Wendt has based upon his clinical and anatomical studies the following conclusions:

"1. In some cases collections of a peculiar matter, resembling greatly the cerumen, are found in the external auditory canal and in the osseous middle ear.

"2. These masses originate in a desquamative inflammation, characterized by a prolific growth and exfoliation of epidermis-scales entirely like the cells of the mucous membrane of the osseous middle ear, the epithelial lining of which, during or after a chronic inflammatory process, may, by exposure to external irritation, through the perforated membrana tympani, assume a cutaneous nature with the formation of a rete Malpighii and external layers, which, on account of the clogging up of the ear and the consequent shutting off of the air, may undergo partial fatty degeneration.

"3. They produce hardness of hearing of a moderate degree when they are dry and loosely placed, and when no greater changes in the sound-conducting apparatus are present. When the opposite conditions prevail, the deafness is of high degree, and pain will be produced if these masses swell, either under the influence of spontaneous suppuration in the middle ear, or of moisture from without.

"4. They can produce important changes in the ear, the petrous bone, and even in the contents of the cranium, by means of the pressure they exert in their vicinity when they soften and swell, and also by their growth; perhaps too their size may increase by absorption of the broken-down fluid elements of themselves or of neighboring pathological formations.

"5. Their removal, though usually attended with pain and tediousness, is absolutely imperative.

"6. It is not improbable that similar masses originating in a chronic inflammation of the walls of the external auditory canal, may pass into the tympanic cavity through perforations in the membrana tympani and produce there the same symptoms (see p. 301).

"7. The collections of epidermis-cells, described in the literature as cholesteatoma of the petrous bone, are likewise to be regarded as products of a desquamative process in the middle ear, until it shall be proven, by a comprehensive study of the masses, that they originate in some other way."

New-formed Membranes and Bands in the Middle Ear.—Morbid membranes and bands occur very often in this cavity, and are very delicate in consistence and of a whitish or gray tint. In the membranes there are deficiencies which can be detected macroscopically; in the synechial bands these deficiencies are seen only under the microscope. All of the above-named new formations (membranes, bands, and cords) may be found in the same ear. Their situation is very varied, they may connect the various walls of the tympanum with one another and with the ossicula, they may be found in the mastoid cells, in connection with the membrana tympani, spread over the round window and the niche of the oval window, the rami of the incus, the stapes, and over the tympanic mouth of the Eustachian tube, and the tendon of the tensor tympani.

Calcareous and osseous deposits may occur in these growths; the functional derangements depend upon the consistence and situation of the latter. The diagnosis of these structures is possible during life if the membrana is thin enough, and Siegle's pneumatic speculum is used to aid in the examination. Respecting the treatment, Wendt laid greatest stress on prevention; the perfectly visible ones may, in some instances, be relieved by operations, which must consist in excision of a part, and not simply incision.[1]

Treatment.—Respecting the treatment, Dr. Trautmann very justly says: "After the pathological process has set in, constant use of the catheter, by stretching and positive atmospheric pressure, will do more in producing atrophy and complete destruction, perhaps entire cure, than an operation in which a piece of the morbid deposit must be cut out in order to prevent fresh adhesion. Such an excision becomes very unsatisfactory, since the remote point of attachment of the morbid ligament cannot be seen."

The Corpuscles of Politzer and Kessel; Wendt's Examination.—Wendt subjected these structures to a careful examination, and concluded that too much importance had been attached to them by their discoverers. He found these thickenings on the cords and bands in the tympanum and mastoid cells in thirty-three per cent. of all cases examined, both in the healthy and in the diseased ear. The form of these bodies is very varied, and by no means as typical as held by Politzer and Kessel. Both Wendt and Trautmann believe that the majority of these bodies are fœtal remnants, though a few of them may be of recent date and of pathological origin. Dr. Trautmann considers them entirely insignificant, unless, on account of their situation and rigidity, they should become mechanical hinderances to the function of the middle ear.[1]

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[1] Prof. Wendt, Archiv f. Heilkunde, 1874, pp. 97–100; also review by Dr. Trautmann, in Archiv f. Ohrenh., Bd. ix. S. 279–281.

Embolism in the Mucous Membrane of the Tympanic Cavity.—In some instances of general embolism and pyæmia, it has been supposed that embolism may occur in the mucous lining of the tympanum.[2] In such a case observed by Wendt, there were found, besides nasopharyngeal catarrh, great alterations in the drum-cavity. The latter consisted in excessive swelling, maceration, and friability of the mucous membrane, which appeared to be stained with the coloring matter of the blood, and filled in its interstices with blood-corpuscles. The stapedes were buried in the swollen membrane, which fact probably helps to explain the great and sudden deafness which preceded death. The changes in this case were referred by Dr. Wendt to embolism of the tympanic artery, but the embolism could not be found *post mortem.*

Malignant Growths in the Nasopharynx, involving the Ear.—Malignant neoplasms in the nasopharynx may involve the ear at an early period of their growth, as shown by the history of the following case of *small-celled sarcoma in the vault of the pharynx:*

On February 26, 1881, Dr. X——, forty-five years of age, a practitioner of medicine in Philadelphia, consulted me respecting an increasing dulness of hearing in both ears, but chiefly in the left, with autophony, and also an altered objective pitch in his voice.

His statements were, briefly, that in 1878 he had suffered from sciatica, and had taken Turkish baths freely as a cure; that he had then experienced what he considered a nasal catarrh, and some hardness of hearing in the left ear, without tinnitus aurium, but with more or less catarrhal resonance in his voice, with autophony. All of these symptoms increased latterly, as he supposed, in consequence of great exposure in his day and night work during the past rigorous winter, and at last he found he could not auscult with either ear. At the same time there was a sensation of moving fluid in his ears when he blew his nose.

Examination of the hearing revealed that the watch was heard, left, $\frac{0}{60}$ in.; right, $\frac{3}{60}$ in. The tuning-fork on the vertex was heard better in the left ear. The voice was heard much better than the watch-sounds. The Eustachian tubes were inflatable by Valsalva's method; the pharynx and anterior nares were only very slightly congested. The left membrana tympani was greatly retracted, and thrown into radiate folds; behind it bubbles were seen distinctly. The right membrane was less retracted, without radiate folds, and bubbles were also seen behind it. Both membranes were therefore punctured, and the tympana evacuated, by Valsalva's method of inflation, of several drops of yellowish, transparent fluid. Both the objective and subjective alteration in the vocal resonance disappeared instantly, and the hearing rose to the normal condition in the right ear, and to nearly a normal point in the left. This relief was maintained until March 8th, nearly two weeks, when the right ear began to grow dull again, and the vocal resonance to return, both apparently caused by a filling up of the tympana, with fluid, as before. Bubbles were seen again, and paracentesis of the right membrane let out a large quantity of yellowish, mucopurulent matter, with the same relief as before. The patient was using at this time a weak solution of sulphate of zinc, 1 gr. to f ℥j—five drops, warmed, in each nostril once daily.

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[1] See review of Wendt's paper, by Dr. Trautmann, Archiv f. O., Bd. ix. S. 281.

[2] Wendt; A. f. O., Bd. ix. S. 121. Abstract by von Troeltsch.

On March 22d the right membrane had to be again punctured for the relief of the previous symptoms; but the left ear showed no bubbles behind the membrane, and hence did not seem to require puncturing. Not so, however, on April 8th, when both membranes required puncturing, which was followed by the same kind of discharge, and consequent relief. The nares, especially the left nostril, now seemed to be growing more stopped, nasal respiration began to grow difficult, and at night painful, the pain being referred to the nucha and occiput. The patient now began to lose flesh and sleep, and became markedly weak in his muscles, and the nasal douche, which he had used once or twice, gave no further relief; in fact, the obstruction in the left nostril became almost total, Valsalva's inflation became more and more difficult, and both taste and smell failed. By April 27th, two months after he was first seen by the writer, Valsalva's inflation had become impossible, and the fluid was drawn from the left tympanum, after paracentesis, by means of suction with Siegle's speculum. The Eustachian catheter caused pain, and its use was not persevered in. The almost constant and great pain in the nucha was probably due to congestion of the vertebral veins. The aural symptoms may be considered due largely, if not entirely, to the mechanical obstruction of the pharyngeal mouth of the Eustachian tubes.

On July 10, 1881, Doctor X—— died. His decline was very rapid from the date of the consultation, notes of which follow. The tumor did not grow downward to any great extent, as it never appeared below the velum. It enlarged sufficiently, however, in that direction to interfere seriously with deglutition and speech, so that toward the end it was necessary to feed him almost entirely by the rectum, and for him to communicate with his friends by writing. About two weeks before his death he took to his bed, and at the same time there were evidences of pressure at the base of the brain.

He had marked converging strabismus, dilatation of the pupils, dimness of vision, and ptosis. He also became very dull and drowsy, sleeping most of the time. His death was comparatively an easy one, and was caused immediately by exhaustion. There was no post-mortem examination. Dr. Harrison Allen, with whom I consulted in this case writes the following sketch of the case from his nasopharyngeal examinations:

"Dr. X—— was seen by me in consultation with my friend, Dr. Burnett, about April 15, 1881. At that time the soft palate was intensely reddened and covered on its anterior surface with a number of nodular elevations, which probably answered to the enlarged and engorged orifices of the glands there situated. The oropharynx was much congested and exceedingly irritable. The nasal chambers were both perfectly normal, the left being the larger. The voice of the patient had a decidedly nasal intonation.

"It appears that about a year ago several attacks of epistaxis had occurred at short intervals, and the nasal intonation became from that time noticeable. At or near the same time a dull pain was experienced in the nape of the neck. The attacks of bleeding have long ceased, but the nasal voice and the nasal pain have persisted and caused Dr. X—— to suspect that he was suffering from his old enemy, rheumatic neuralgia, with a complication of nasal catarrh. At the time of the above examination, nasal respiration was almost impossible. Examination was much interfered with by the almost incessant efforts of the patient to clear the pharynx of tenacious mucus.

"The rhinal mirror detected a swelling on the left side of the vault of the nasopharynx. The Eustachian fossæ were congested, but in other respects appeared to be normal. The finger, being introduced into the nasopharynx, defined the swelling to be of the size of a chestnut, having a broad base and almost entirely occluding the left posterior naris. Considerable bleeding ensued upon the manipulation, and the patient acknowledged more distress than usually follows this rather disagreeable test.

"April 22d, I saw the patient again, and succeeded in detaching a portion of the pharyngeal mass with the finger. This fragment, when submitted to Dr. Carl Seiler for microscopical examination, was found to be a portion of a small-celled sarcoma.

"I saw Dr. X—— on three other occasions, but had no reason to change the opinion previously formed, that the patient was suffering from a vascular malignant growth at the pharyngeal vault, sessile in form and occluding the posterior naris of the left side.

"The treatment was simply palliative, though the doctor was informed that an operation was, in my judgment, justifiable. The operation I proposed was a removal of the projecting mass in the pharynx, with the object of increasing the degree of nasal breathing. But the idea of an operation was so repugnant to the patient's feelings that the proposition was not urged. It was well that nothing of the kind was attempted, for, in the light of subsequent events, such a procedure would most likely have simply precipitated the fatal issue.

"I saw the case for the last time in consultation with Prof. D. H. Agnew, who confirmed the views entertained by Dr. Burnett and myself, as to the nature of the case. The mass had by this time extended across the vault, and the degree of pharyngeal congestion had greatly increased.

"A word of explanation is demanded respecting the nasal respiration. The mass, while lying on the left side, is described as occluding the left naris only; yet the arrest of the nasal respiration was absolute. It has already been seen that the left side of the nose was the larger. There is no doubt that nasal breathing was carried on almost entirely on the left side, and when this side was filled by the growth, the general congestion of the pharynx was sufficient to occlude the already narrowed right chamber."

Primary Cancer of the Middle Ear.—Cancerous disease often passes from neighboring tissues to the middle ear, as, for example, in cancer of the auricle,[1] cancer at the base of the skull,[2] malignant disease of the parotid gland,[3] and of the antrum of Highmore,[4] but cases in which it can be shown that the primary seat of the cancer has been in the middle ear are extremely rare.

Instances of primary cancer of the middle ear have, however, been recorded by Toynbee,[5] Billroth,[6] Wilde,[7] Travers,[8] Wishart,[9] Böke,[10] Robertson,[11] and Schwartze,[12] as referred to by the latter.

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[1] Gruber, Lehrbuch, p. 596.

[2] Türck, Zeitschr. der K. K. Gesellschaft der Aerzte zu Wien, 1855.

[3] Schwartze, Archiv f. Ohrenh., Bd. ix. S. 215.

[4] Schwartze, Ibid.

[5] Diseases of the Ear, chap. xvii.

[6] Archiv f. Klin. Chirurgie, x. 67.

[7] Quoted by Schwartze, loc. cit. Osteo-sarcoma.

[8] Froriep's Notizen, Bd. 25, No. 22, S. 352.

[9] Edinburgh Med. and Surg. Journal, vol. xviii. p. 393.

[10] Wiener Med. Halle, 1863, Nos. 45 and 46.

[11] Transact. American Otol. Soc., 1870.

[12] Archiv für Ohrenh., Bd. ix. S. 208, 1875.

History, Course, and Symptoms.—In most cases there is a history of previous chronic purulent discharge, from the ear, which finally becomes the seat of the primary cancerous disease. The purulent affection may continue for a long time before the symptoms of the malignant disease appear. These are usually more or less sudden hemorrhages, with a more acrid and fetid discharge from the ear, and, at the same time, the ear becomes the seat of constant and increasing pain. Sensitive and exuberant granulations fill the canal. The parts about the ear may become swollen and infiltrated, at last breaking down into ulceration. Death may ensue before the disease breaks through the cutaneous tissues about the ear; but all the osseous parts to which the external ear is attached may be destroyed.

An abscess not uncommonly forms over the mastoid portion, and in a short time sequestra may escape from the sinus left by the circumscribed inflammation. The hemorrhages may now become less frequent, but a discharge more or less copious and of a sanious nature still continues from the ear. The hearing is, of course, greatly impaird, and if the tuning-fork is not heard on the vertex, it may be concluded that the disease has invaded the labyrinth.

Facial paralysis may ensue, and the glands near the ear usually become infiltrated and may suppurate. As the tissues about the ear break down, forming ulcers with eroded edges, the hemorrhages from the ear increase in amount and frequency, the pain is terrific, and the fetor intolerable. In the case reported by Schwartze, the palate became paralyzed on the affected side. Finally the patient dies from exhaustion.

Etiology.—Malignant disease of the ear most usually originates in the mucous lining of the tympanum.[1] Malignant disease in an ear previously affected with chronic and neglected otorrhœa, may have its origin in the latter process.[2] Some of the cases of death supposed to be due to the removal of aural polypi, should have been referred to an extension of a malignant disease, rather than to the excision of a tumor.[3] Malignant growths in the middle ear are usually the result of extension thither from neighboring parts, as, epithelial cancer from the external ear, and fibrous and medullary carcinoma from the pharynx or from the dura mater.[4] This seems to be confirmed by observations of cases by Moos,[5] O. D. Pomeroy,[6] Sune y Molist,[7] Assaky, Polaillon,[8] and others.

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[1] Toynbee, op. cit., p. 386.

[2] Schwartze, op. cit., p. 218.

[3] Roosa, Treatise, p. 394.

[4] Gruber, Lehrbuch, p. 596.

[5] American Journal of Otology, vol. i. p. 299, 1879.

[6] Ibid., vol. iii. p. 98, 1881.

[7] Ibid., vol. iv., 1882. From Gaceta Medica Catalana, May 15, 1882.

[8] Annales des Maladies de l'Oreille, Nov. 1879.

Treatment.—It has generally been supposed that treatment is futile in these cases, but Schwartze claims to have obtained beneficial results from perforation of the mastoid process, when the disease has seemed to be extending inward, or to be pent up in the tympanum and mastoid cavity.

Cancer of the Mastoid Portion.—The mastoid process may become the seat of cancer, as shown by Rondot.[1] Its history and symptoms are similar to those given as characteristic of primary cancer of the middle ear, inasmuch as it seems to be a consequence of neglected chronic otorrhœa.

The earliest symptoms, besides the chronic aural discharge, are hemorrhages from the ear, soon followed by intense pain and swelling of the mastoid and the parts about the seat of the disease, great deafness, and tinnitus aurium. As the disease advances, facial paralysis may ensue, the mastoid portion becomes more swollen and painful, the extreme point of the process may be most tender, giddiness and vomiting are apt to be joined to the other symptoms, and the entire mastoid region is covered with suppurating and fungoid nodules.

Emphysematous Tumor over the Mastoid Portion.—Natural dehiscences in the mastoid portion of the temporal bone sometimes persist, and favor the escape of air from the middle ear and mastoid cavity to the skin lying over the latter, as has been observed in a case reported by Prof. Wernher,[2] of Giessen.

This curious affection may show itself suddenly after an ordinary act of sneezing, in the form of a tumor, the size of a pigeon's egg, over the mastoid. There is no pain attending its formation, and the patient may be entirely unconscious of its occurrence. So perfect may the connection be between the mastoid cavity and the emphysematous tumor, that gentle pressure will force the air from the latter into the middle ear and fauces; but renewed expiratory efforts will reproduce the tumor. Gradually such a formation over the mastoid may extend, until the entire corresponding half of the scalp is involved, and the latter is lifted at some points 1½″ to 2″ above the skull, as was observed in the case referred to.

The middle ear and membrana tympani may be normal, but a large dehiscence, the remnant of the natural openings in the infantile bone, may be found running across the entire mastoid portion, as in the case reported by Wernher. Compression long kept up, having failed, in the case reported, to produce a cure, a successful endeavor was made to set up adhesive inflammation between the edges of the dehiscence and the superjacent soft tissues. This was accomplished by means of subcutaneous injections of tincture of iodine at various points in the tumor.

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[1] Ibid., p. 227, 1875.

[2] Deutsche Zeitschrift für Chirurgie, Bd. iii.; also Archiv für Ohrenh., Bd. ix.

Hairs in the Mastoid Cells.—Another curious condition of the mastoid cavity is the following, related by the late Mr. Toynbee. He showed[1] a specimen of hairs in the mastoid cells, and said that according to his experience the case was unique. The hairs were firmly embedded in the mastoid cells, and surrounded by masses of epidermis. Dr. Tilbury Fox, who examined them, agreed that the hairs could not have been introduced from without, but were nourished in the cells.

Traumatism of the Mastoid.—Serious wounds[2] and fractures[3] occur in the mastoid portion of the temporal bone. The following case of injury of the mastoid is of great interest, as it shows how great a perforating wound of the osseous substance this part of the bone can sustain without fatal results, and furnishes a strong argument in favor of the impunity of careful surgical operations on this part of the ear.

Fracture of the Mastoid Portion, Followed by Facial Paralysis.—On November 3, 1881, John McMurray, twenty-four years old, a brakeman, was admitted to the surgical ward of the Presbyterian Hospital, Philadelphia, during the service of Dr. Thomas B. Reed. At the time of his admission he was insensible, and remained out of his mind for two weeks thereafter. There was a wound running horizontally backward from the meatus, entirely through the auricle, and communicating with a deeper wound which extended into the mastoid portion and the posterior bony wall of the auditory canal, so as to throw these two cavities into one.

Upon returning to consciousness his statement was, that on the 3d of November, while on duty as brakeman on a freight train, he was struck behind the left ear. He could not say how or by what he was struck. He was found insensible and bleeding on top of his car, where he had fallen while putting on the brake.

The sterno-cleido-mastoid muscle was cut from its insertion, there were marked facial paralysis and hardness of hearing on the injured side, and there had been considerable hemorrhage, both before and after admission to the hospital.

The writer examined the case, for the first time, November 29th, in the Ear Department of the Dispensary connected with the Hospital, and found the patient very weak, with the left side of his face greatly paralyzed, and a disposition to lose his vision for a few moments upon turning in bed, or rising suddenly. The wound in the auricle had already healed. The auditory canal was somewhat obstructed with granulations in its deeper parts, but at the point of junction between the bony and cartilaginous parts, on the posterior wall, the canal communicated with the wound cavity in the mastoid. A movable piece of bone, spongy-looking behind, but rather smooth in front, that is, towards the auditory canal, lay in this wound and was easily pushed backwards and forwards, both from the auditory canal and mastoid wound. This piece of bone was pushed so far forwards into the calibre of the canal, as to hide the drum-head from view, except at its upper and anterior quadrant.

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[1] From the report of the Pathological Society of London, in the Medical Times and Gazette, March 3, 1866, p. 238.

[2] Bürkner, Archiv für Ohrenheilkunde, Bd. xvi. S. 59, 1880.

[3] Kirchner, Ibid., Bd. xix. S. 257, 1883.

The patient could not hear words on this side, nor the tuning-fork by aërial conduction, but the fork vibrating on his vertex was most distinctly heard in the wounded ear. As no perforation-whistle was ever produced, either by Valsalva's or Politzer's inflation, the diagnosis limited the disease to the outer ear and the mastoid portion.

On December 16, 1881, the aforesaid movable piece of bone became detached from the soft parts and was removed. The drum-head now became more visible, only about one-third being hidden from view by a granulation on the posterior wall of the auditory canal; but no perforation in it could be detected. The hearing also improved, words being heard a foot off. The piece of removed bone was about one-half an inch in length and breadth, and three-eighths of an inch thick, rather smooth on the surface towards the auditory canal, but evidently composed of mastoid cells, traversed by a distinct canal which resembled in calibre the facial canal. Upon holding this piece of bone in such a position as to correspond with a similar part of a normal temporal bone of the left side, the canal running through it was found to correspond with a part of the facial canal, not far from the stylo-mastoid foramen. Hence the facial paralysis must be explained by the assumption that the facial canal and its nerve were severed by the blow which had penetrated the mastoid portion of temporal bone.

An ophthalmoscopic examination revealed on the right side a quite prominent, choked disk; the veins decidedly swollen, disk very red; the arteries diminished in size, their coats white and glistening; an especially white patch on nasal side of disk; the right pupil considerably larger than its fellow. On the left side the same condition was found, but it had been of longer duration.

The patient's condition continued to improve, however, in every respect, excepting in the paralyzed state of his face. The hearing improved, he ceased to lose his sight upon sudden motion, and he was finally dismissed January 2, 1882, at his own request, the wound in the mastoid having closed, and the calibre of the auditory canal being nearly perfect.

He was seen a few months later, appeared in very good health, the hearing was very good, but the facial paralysis remained.

CHAPTER V.

ACUTE PURULENT INFLAMMATION.

THE disease previously treated of, catarrhal inflammation of the middle ear, is characterized by its tendency to harden and stiffen the original tissues of the ear, and in some cases to develop hypertrophy of the same. But purulent inflammation of the middle ear, which it is now proposed to consider, is characterized, both in its acute and chronic form, by its tendency to break down and to destroy the tissues of the ear invaded.

These two distinctions cannot be too constantly kept in mind, when endeavoring to study diseases of the middle ear, for it will be found upon careful examination that every inflammation invading the mucous membrane of the middle ear, in the vast majority of instances, must be placed in one of these two general divisions. Already it has been shown that catarrhal inflammation of the middle ear is conservative of tissue, and limits itself strictly to the ear. But there is a large number of cases of inflammation of the mucous lining of the middle ear, which tend at the outset to the formation of pus. This form of inflammation of the middle ear, not only breaks down and destroys the tissues of the ear, but it is characterized by its tendency to invade other parts of the head, especially the cranial cavity. In this virulent form it not unfrequently produces pyæmia, embolic diseases in the abdominal and thoracic viscera, cerebral abscess, and death.

SUBJECTIVE SYMPTOMS.

The subjective symptoms of acute purulent inflammation of the middle ear are usually very rapid and violent in their succession. They are chiefly itching and tickling, referred to the Eustachian region and the ear; a sense of fulness and unintermittent pain deep in the ear, which is greatly increased by coughing, sneezing, talking, or eating; tenderness of the adjacent maxillary articulation (though the latter symptom is not as marked in this disease as it is in inflammation of the external auditory canal); vertigo; tinnitus aurium; and hardness of hearing.

To these distressing symptoms in the ear, is added pain in the side of the head corresponding with the affected ear, running forward to the eye, temple, and frontal sinus, and backward to the occiput.

The condition of the sufferer becomes at last most pitiable; every movement of the head and body causes intense agony, the eyes roll about in a frenzy of pain, no comfortable position can be obtained either in sitting or in lying down, and even the strongest man may be forced to shriek, so dreadful is the suffering from acute purulent otitis media. If the victim is an infant or young child, all these symptoms may be mistaken for another disease, very often for incipient brain-disease, and this erroneous opinion is all the more confirmed by the not uncommon convulsion, into which the child may be thrown by its frightful sufferings. Usually these symptoms are relieved by a spontaneous rupture of the drum-head and escape of purulent matter. But this result will be more fully discussed under the consideration of the objective symptoms of the disease.

It becomes, indeed, one of the prime duties of a physician to be on the lookout for the acute occurrence of this disease in children, for upon its timely recognition may depend the life of the little patient. Certainly much suffering would be avoided, perhaps many lives saved, if the ear were even once thought of as the possible cause of an apparently obscure disease, in those too young to tell where the seat of their pain is.

Not only in children, but in adults, this disease is one of the *most* important the physician meets. The importance of treating it properly in its acute stage cannot be too highly estimated. Yet it is lamentable to state that it is usually entirely disregarded.

Itching in Throat and Ear.—The itching and tickling of this disease are felt running from the throat, along the Eustachian tube, and to the depths of the ear, or *vice versâ*. This is due to a direct passage of the inflammation from the throat to the ear, in some cases; in others, it is purely reflex, like ear-cough.

Very often this sense of itching is the first symptom which calls the attention of the patient to his ear. It may, however, be entirely overlooked, and the ear is disregarded, until sharp pain in it arrests the attention of the sufferer.

Pain.—In the pain of acute purulent inflammation of the ear, we have perhaps the earliest diagnostic symptom of this disease. It will be found that, as a rule, the severity and continuance of pain is much more marked than in the catarrhal form of inflammation of the middle ear.

As has been stated, the pain in that disease is never so intense as in acute purulent inflammation of the ear, and it very often remits during the daytime; but the pain in the acute purulent disease often leaps at once to an unendurable severity, and, if left to itself, is eased only by the escape of puriform matter from the tympanic cavity. While the pain of the former is often not severe enough to keep the patient from his daily avocation, the pain of the disease under consideration is usually so intense as to excite secondary symptoms of fever, and in some cases delirium.

Alteration in Hearing.—At the beginning of this disease the hearing may become abnormally sensitive, and ordinary sounds will cause increase of pain in the ear. The patient's own voice may also give him pain. As the inflammation advances and its results are more fully established, the hearing will grow dull, and by the time secretion is fully established, the deafness may be great.

The subjective noises are usually very annoying, and in many cases very distressing. Concerning tinnitus aurium and all kinds of so-called subjective aural sounds, the reader is referred to page 352.

Vertigo, Fever, and Delirium.—Vertigo may be a symptom in this, as in many other aural diseases. It seems most marked after secretion is established, and before the membrana tympani is ruptued. It is, therefore, apparently due to pressure communicated to the labyrinth. It often continues, however, after rupture in the membrana tympani.

Fever and delirium, excited by the intense acute inflammation, must be treated on general principles, with this exception, that cold applications to the head, near the affected ear, should be avoided. While cold may allay inflammation elsewhere, no good results can come from its application to an acutely inflamed middle ear. This is due to the specially bad effects of cold in any form upon the ear.

OBJECTIVE SYMPTOMS.

Membrana Tympani.—If the drum-head is examined in the early stages of this disease, it will be found congested at its periphery, and markedly about the membrana flaccida and the malleus. Gradually this congestion spreads inward from the periphery and outward, *i. e.*, backward and forward from the manubrium of the malleus, until the entire drum-head is decidedly pinkish, with especially deep shades in its upper half.

When so much congestion has occurred, the usual contour of the membrane will be less marked, the handle of the hammer will be less distinct, and the lustre of the dermoid layer, and the pyramid of light will disappear. Vesicles may form on the membrana tympani at this point of the disease, but they are not common. The normal features of the drum-head are thus made to vanish, but in the lighter cases they may not become more distorted than above described, while in the severer cases the congestion and swelling of the membrane become so great that, at the fundus of the canal, there is only an undefined and sodden red diaphragm in the place of the normal drum-head.

Spontaneous Rupture of the Membrana Tympani.—This event is to be regarded as a chief symptom of purulent inflammation of the middle ear. Whatever may have been the nature of the inflammatory action in the tympanum at the outset, it will be found that when the disease has advanced so far as to produce spontaneous rupture of the membrana tympani, the matter discharged through such a ruptured spot will be of a purulent nature. This is in keeping with the tendency of the disease to break down tissue. Mucus in large amount may accumulate behind the membrana tympani, and, after clogging the tympanum for a time, be absorbed. It cannot be shown that if pus forms in the tympanum it is ever absorbed, or, if let alone, it escapes in any other way than by spontaneously rupturing the membrana tympani. Nor does nature long delay the rupturing of the membrana tympani after pus has formed in the tympanic cavity. But mucus may lie in the tympanum long after all acute symptoms have subsided, and is usually the cause of the continued deafness after a comparatively slight attack of catarrhal congestion and inflammation.

In acute purulent inflammation of the tympanum, the membrana tympani will be found to be bulging very soon after the onset of the acute symptoms, unless the membrana tympani is broken down early in the inflammatory process. The bulging is usually confined to the posterior half of the membrana tympani, because all the efforts of blowing the nose, sneezing, and the like, force the products of inflammation backwards toward the hinder part of the tympanic cavity.

COURSE.

The course of acute purulent inflammation may, therefore, be said to tend to a greater or less destructive process in the mucous lining of the cavity of the tympanum, and to rupture of the membrana tympani. The latter event is usually the first destructive result of the disease, and is very likely to give relief to pain. In some of the more violent cases, pain may not only continue, but increase after the rupture of the membrane. In such cases, a well-grounded suspicion may be aroused that the disease has invaded parts deeper than the mucous lining of the drum-cavity, and that it is likely that either the mastoid cells, or the cranial cavity, or both, may have become affected.

Authentic accounts of death resulting directly from acute purulent inflammation of the ear are rare—though doubtless death has occurred from this disease in its early stages, but has been set down to other causes. Death from the chronic form is a common occurrence.

Possible Fatality of the Acute Form of Purulent Inflammation of the Middle Ear.—It is a great misfortune, but one to be attributed to the hitherto imperfect means of examining the ear, and the consequent ignorance concerning the processes which go on there, that so few positive and accurate facts can be found as to the number of deaths occurring from acute purulent inflammation in a previously healthy ear. Most writers mention its occurrence, but few give details of cases.

Toynbee[1] found that the dura mater partook in the tympanic inflammation of typhus fever, which fact would seem to indicate that the tympanic disease shared largely in the fatal result. Bezold[2] has found that the tympanum is attacked by purulent inflammation in four per cent. of all cases of typhoid fever. Itard, quoted by Toynbee, gives an authentic account of death in a short time after the onset of acute tympanic disease, the latter being undoubtedly the cause of death. Wilde[3] says death occurs frequently from acute inflammation of the ear, among the lower classes in Ireland; but he gives no account of these cases, probably because he considered them so well known as to need no illustration.

Dr. Edward H. Clarke,[4] of Boston, has narrated a case occurring in his practice, of a boy, in whom the acute inflammation of the middle ear proved fatal in fourteen weeks after its onset, by producing an abscess in the brain. In this case the inflammation of the middle ear passed through the tegmen tympani and thence to the brain. "The moisture and redness of the petrous bone at that point served to mark the track of the disease."

This case was of three weeks' standing when Dr. Clarke first had the opportunity of treating it, and he very justly observes: "If it had been possible to arrest the disease when it first attacked the ear, and before the bone, or rather the periosteum, was invaded, the life of the patient would probably have been saved."[1]

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[1] Op. cit., p. 320.

[2] Archiv für Ohrenheilkunde, Bd. xxi., 1884.

[3] Diseases of the Ear, p. 241.

[4] Archives of Scientific and Practical Medicine, Jan. 1873, No. 1.

I saw, not long since, in the Philadelphia Infirmary for Diseases of the Ear, a case of acute inflammation of the tympanic cavity, in a woman thirty years old, which proved fatal in less than a month, by an extension to the mastoid cells and brain. The patient rejected the treatment proposed to her, viz., trephining the outer wall of the mastoid portion, and did not return to the Infirmary; but I learned from her friends that she at last succumbed, with every symptom of most violent inflammation of the brain.

Though these cases show the course acute inflammation of the drum-cavity may take, it usually pursues a more favorable course. But they show the importance of early and intelligent treatment.

Darolles[2] has given an account of acute otitis media purulenta of the *right* side, followed by facial paralysis on the same side on the tenth day; acute meningitis was caused in this case by irruption of the pus into the aqueduct of Fallopius. On the sixteenth day profuse sweating, involuntary discharges of urine and feces, paralysis of the *left* arm, dilated pupils, reacting sluggishly, thready pulse, temperature 40.6° C., were noted. Death occurred the same evening. The post-mortem examination revealed: Veins of the pia and dura mater greatly congested; copious purulent infiltration into the subarachnoid cellular tissue, confined chiefly to the base, and the convexity of the right hemisphere; on the left side only those portions of the brain overlying the sphenoid bone were affected. Small insulated purulent foci were found along the bloodvessels of the convexity of the brain. The pia mater adhered at several points to the gray substance.

The outer surface of the petrous bone presented no abnormal feature, but the tympanic cavity was filled with pus, in which the ossicles floated about free. A small perforation the size of a pin-head was found in the upper segment of the drum-head; the mastoid cells were also filled with pus.

The facial nerve was exposed as far as its second turn, at the Fallopian hiatus, and was covered throughout its course with thick pus. The other walls of the tympanum were normal.

Dr. Gähde[3] has related a case of death resulting from an acute purulent inflammation of the middle ear. The patient was a young private soldier, under Dr. Gähde's observation in Magdeburg, Germany. The acute symptoms occurred on the 27th of

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[1] Loc. cit., p. 47.

[2] Bulletin de la Société Anatomique de Paris, 1 fasc., 1875. See review by Kuhn, Archiv f. Ohrenheilk., Bd. x. S. 258.

[3] Archiv f. Ohrenheilk., N. F., Bd. ii. S. 98.

August, but appeared to subside after a slight discharge had occurred from the affected ear, the right. By the 12th of September, however, the discharge from the ear and the pain having in the meantime ceased, the patient complained once more of pain in the ear, and his mastoid portion was found to be very sensitive to pressure. Notwithstanding rest in bed and free leeching behind the affected ear, cerebral symptoms set in, and on the second day after the appearance of the symptoms the man died.

The post-mortem examination revealed that the pus had accumulated in the tympanic cavity in large amount, but instead of bursting through the membrana tympani a second time, and thus saving the life of the patient, it had forced its way into the mastoid cavity, and thence through a defective spot in its posterior wall, until the products of inflammation were brought in contact with the dura mater. This, of course, set up an irritation in the covering of the brain, and fatal meningitis soon followed. A free opening in the membrana tympani might have saved this man's life.

I have observed, not infrequently, that a perforation in the membrana tympani will heal up after giving vent to some of the products of inflammation in the tympanum, but before the cavity is entirely drained. If the case is watched now for several days, it will be found that there is a return of pain, and the drum-head will be seen to be bulging again. Disease may have already thickened it so much that it will not give way as quickly as it did before, and therefore it becomes imperative to open it artificially, and allow whatever may have accumulated behind it to escape. In some cases, before the acute process had entirely disappeared, I have found it necessary to puncture the membrana tympani a second time.

ETIOLOGY.

The most usual causes of acute purulent inflammation of the middle ear are the exanthemata, local cold in various forms, and direct violence to the ear. The first two are well known as the most fruitful sources of this severe malady. Whooping-cough also very often produces acute purulent disease of the tympanum.

When acute purulent inflammation arises in these diseases it is always a serious complication, chiefly because it is either unrecognized or neglected for the supposed sake of more attention to the general disease. The latter, however, can receive every possible attention, while the ear-disease gets its share too.

Even if the attention is not drawn to the ear by symptoms of aural disease, the knowledge that the latter is likely to occur in the already named maladies, should prompt an early and careful examination of the ears in *every* case of exanthematous disease. If the treatment of the ear were made an important part of the general treatment, the latter would certainly be more effectual in the exanthemata, for not only would the general disease run a more favorable course in its acute stages, because relieved of a most painful complication, but there would be less chronic purulent disease of the ear with its dreadful results, following in the track of the above-named affections. Mr. Hinton,[1] of London, was of the opinion that the mortality from scarlatina might be diminished by bestowing care upon the ears when affected by that disease.

Cold Bathing; its Effect on the Middle Ear.—The effect of cold bathing on the ear has received of late a good amount of the attention due it. The exposure of the ear to cold water, in diving, sea-bathing, and the like, seems to be a very common cause of acute inflammation in the middle ear. While it cannot be denied that sea-bathing applied to the general cutaneous surface may be very beneficial in certain forms of ear-disease, the contact of cold water with the membrana tympani is always fraught with danger to the ear.

Therefore all forms of cold-water bathing must be so conducted as to preclude this dangerous contact of cold water with the drum-membrane. This can be done only by keeping the head above water, or by stopping up the external ears, if the head is to go under the surface of the water. This may seem an extreme view, and it may be said that thousands bathe without incurring acute inflammation in the ear. Such may be the case, but while acute processes may be avoided, it is equally certain that the frequent contact of cold water with the membrana tympani, lays the foundation of *chronic* deafness of a catarrhal variety. In the latter case the conservative force of nature thickens the drum-membrane in order to resist the frequent assaults of the cold water, which is allowed to enter the external auditory canal. The frequent entrance of cold water into the external auditory canal induces a tendency to a chronic dermatitis and periostitis of that part of the ear.

It is noteworthy that no mammal but man goes voluntarily under water, without being provided with a means of preventing the water from running into the ears. It is a fact well known to many that hunting dogs *taught* to dive, become deaf.

Acute Inflammation of the Tympanic Cavity produced by Concussion.—Now and then an acute inflammation in the drum-cavity is set up by a fall, a blow upon the auricle, or an explosion near the ear. In such a case the traumatic force seems to be the powerful compression of the air in the external auditory canal and tympanic cavity, brought about by the sudden concussion.

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[1] Questions of Aural Surgery, p. 133.

These cases are entirely distinct from cases of deafness resulting from concussion of the nervous apparatus of the ear. In the latter we find deafness, unattended by any signs of acute inflammation of the middle ear, the only symptom.

When an acute inflammation in the middle ear is caused by a fall, an explanation may be sought for in the peculiar way in which the force of the fall is spent upon the air of the tympanic cavity. The concussion of the air in this cavity may be so powerful as really to wound the mucous membrane. As no direct violence is offered to the middle ear in these cases, the inflammation must be due to the effect of the violent oscillation of the air in the tympanic cavity.

I have seen but one case of acute inflammation of the middle ear resulting from a fall, and that was in Politzer's clinic, in Vienna, in 1872. Prof. Politzer stated, at that time, that "he had seen a few cases of what he termed *traumatic* catarrh[1] of the middle ear, a disease entirely distinct from those forms of disease resulting from concussion of the cochlea."

Acute Purulent Inflammation of the Tympanic Cavity, from a Blow on the Auricle.—I have observed acute inflammation in the tympanic cavity, following a blow on the auricle, in a boy thirteen years old, who was struck on the ear by a ball.

There was, in this case, very little external otitis, the auditory canal remained unswollen, though rather more tender than usual, there was pain deep in the ear, with tinnitus and deafness, great redness and swelling of the membrana tympani, perforation of the same, and a discharge of blood, mucus, and pus from the tympanum. Mastication was painful to the affected ear, and the boy lost appetite and strength. Inflation of the tympanum was easily done by the method of Valsalva and by that of Politzer, showing no obstruction in the Eustachian tube. The ear was syringed regularly each day with warm water, and mild astringents were instilled into it, tonics were given, and in six weeks the boy began to recover his health and hearing, both of which were finally restored. Concussion plainly caused this case of tympanal inflammation. Its mode of action was by a sudden compression of the column of air in the auditory canal, as the ball struck the auricle, and by a consequent forcing inward of the membrana tympani, and a violent shaking of the delicate structures in the middle ear.

Very interesting cases of this kind of acute inflammation of the middle ear produced by concussion, are four reported by

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[1] Saissy alludes to a similar form of disease, English translation by N. R. Smith, Baltimore, 1829, p. 109.

Dr. J. Orne Green.[1] Two of these cases of acute tympanal disease were caused by an explosion[2] of a bag of gas, one by a blow on the ear from a policeman's club, and a fourth by a fall thirty feet, upon the head. In all of these cases the drum-membrane was ruptured by the traumatic force, and in the first three purulent, and in the last-named simple, catarrhal inflammation ensued. These cases are examples of accidental injury to the sound-conducting apparatus of the ear, and should be carefully diagnosticated from cases of partial or total loss of hearing, from accidental injury to the brain or nervous structures of the ear. Such cases become of the greatest importance in legal medicine on account of the accuracy of diagnosis demanded by their occurrence.

Not long since, an intelligent man presented himself for treatment of deafness and tinnitus resulting, as he said, from a blow on the ear, from a policeman's club, a few days before. He stoutly asserted the integrity of his ear before the blow, but after removal of dried blood from the auditory canal I found an unmistakably chronically diseased drum-head, and, on examining the fauces, a markedly granular pharynx. On the next day, after the drum-head had become dry from the water syringed into the ear, it was found to be lustreless and retracted, the handle of the malleus prominent and twisted on its long vertical diameter, and the lower segment of the drum-head contained calcareous spots. The Eustachian tube was pervious to the air of the catheter.

With all these features of chronically diseased throat and a more or less atrophied drum-head, an opinion as to the *cause of deafness* should be given guardedly. It is well known that a progressive hardness of hearing may advance very far, before the attention of the patient is drawn to it. In the case just mentioned, it appears probable, to one familiar with aural disease, that the blow from the policeman's club was not the sole cause of the deafness, yet, at the first recital of such a case, one naturally thinks immediately of an acute injury to the nervous structures of the ear.

DIAGNOSIS.

In the diagnosis of this disease there are several prominent subjective and objective symptoms for guidance. In the first instance, the severity of the pain will be so much greater and persistent than that of acute catarrh, that it alone will aid in forming a true diagnosis, and the general systemic disturbance which also accompanies it, will be an additional evidence as to the real nature of this disease. With all this intense pain in the ear, we may be surprised to find the auricle and meatus not sensitive to gentle traction. This latter feature of the disease should at once free our minds from the idea that the pain is caused by any form of external otitis.

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[1] Transactions American Otological Society, 1872.

[2] One of the two cases caused by explosion was under the care of Dr. Shaw, to whom Dr. Green acknowledges himself indebted for the notes of the case (loc. cit.).

In either the circumscribed or diffuse variety of external otitis, the slightest manipulation of the auricle and auditory canal is usually attended with pain. The objective symptoms, too, in external otitis, enable us to form a diagnosis between it and acute inflammation in the middle ear. The differential diagnosis becomes more difficult when there is a diffuse external otitis consecutive to the tympanic inflammation, especially if the former should close the auditory canal. This closure, however, is not so likely to occur in the *consecutive* as in the *idiopathic* form of external otitis. Another aid in diagnosis is the fact that diffuse external otitis, consecutive to an acute inflammation of the middle ear, is comparatively rare, and not very rapid in its onset. Before it appears, an opportunity is generally afforded to examine the membrana tympani and establish a diagnosis of the original tympanic disease. If doubt is still present, as to the condition of the drum-cavity, its state must be further determined by the use of the Eustachian catheter, inspection of the fauces and nares, and a careful noting of all the general symptoms.

Earache from Decayed and otherwise Diseased Teeth.—The pain of acute inflammation of the tympanic cavity may be confounded with that caused by diseased teeth, and other dental irritation. Von Troeltsch has already noticed that it is often difficult to distinguish pain in the molar teeth from pain in the middle ear. Many cases of earache occur, not only in those with neglected carious teeth, but in the more fortunate whose teeth are filled with gold. In the latter, otalgia is often produced by inflammation and caries beneath the filling. I see constantly many cases in the former class, in the Infirmary, and now and then cases of the latter variety present themselves in private. Although, in such cases, the objective aural symptoms would remove all doubt from the mind of one familiar with the appearances of a normal ear, still, the possible cause of pain in the ear, arising from diseased teeth, should be borne in mind until the diagnosis of a different cause is fully established. Whenever we find earache without sufficient objective symptoms of its cause, it is never amiss to inquire after the condition of the teeth.

Rau[1] says that, in young children, dentition is always attended with irritation in, and sometimes discharge from, the skin lining the external auditory canal. (See p. 89.) The fact that an unchanging pain is usually the *only* symptom present in otalgia due to a diseased tooth, will aid the diagnosis.

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[1] Ohrenheilkunde, p. 158, Berlin, 1856.

Upon reviewing the records of fifteen hundred cases of ear-disease observed by him, Sexton[1] found that the teeth are the seat of disease more frequently than was at first suspected, and of these cases, fully one-third owed the origin and continuance of their aural malady to the dental disease, to a greater or less degree. This excitation of disease in the ear by diseased teeth, gums, and buccal surfaces in the mouth, is succinctly explained by the continuity of nerve-fibre—not simply a continuity of sensori-motor nerve-fibres, but in the relation of the vaso-motor nerves and their functions (Woakes).

Sexton further states that the ear begins to suffer from sympathetic dental irritation from the time of the appearance of the two central incisors of the lower jaw; that during second dentition the mouth has but little rest, and hence there may be reflected from it an irritation in the form of engorgement, to the middle ear, and hypertrophy of the gums and epulis may be regarded as probable causes of aural disease in later years.

He also draws attention to possible detrimental action on the mouth, and thence upon the ear, from bad plates holding artificial teeth, and from poisonous substances entering into fillings for cavities (especially amalgams containing mercury).

Appearances of the Membrana Tympani.—The general alteration of the membrana tympani is more intense in acute purulent otitis media than in the catarrhal form. The membrane will be found passing from a stage of congestion around its periphery and malleus, to successive ones of greater intensity, until all its contours are lost, and either a bulging or a misshapen diaphragm is seen at the fundus of the auditory canal. But we cannot point out any specific symptom in the membrana tympani as peculiar to this disease; it is rather the general and severe implication of the whole membrane that would seem to distinctively mark its condition in this disease.

Whenever any matter collects behind the membrana tympani in quantities large enough to force the latter to bulge, such protrusion is almost invariably in the posterior half of the membrane. If the membrane has not been thickened by previous catarrhal disease, it is more apt to give way spontaneously in the acute purulent form than in the acute catarrhal form of otitis. Bulging is hence more common in the latter than in the former disease.

Whenever the membrane appears to be in hillocks, or puckered, there is most probably exceptional implication of its dermoid layer, in all likelihood due to a consecutive diffuse external otitis. The latter may not advance further outward than the immediate region of the membrana tympani; or it may, unfortunately, invade the entire external ear.

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[1] American Journal of the Medical Sciences, Jan. 1880.

PROGNOSIS AND TREATMENT.

The prognosis in properly treated acute purulent inflammation of the middle ear, though usually favorable, must always be modified by the cause of the disease and the general condition and age of the patient. The cases arising in acute exanthemata are the least favorable, because usually neglected. Those occurring in an ear previously diseased, or in one occluded to an extent likely to prevent the escape of the products of inflammation, must be considered as gravely complicated, not only as to the hearing, but as to the life of the sufferer. An ordinary uncomplicated case of acute inflammation of the middle ear, arising from cold or from traumatic violence, is rarely fatal to life. This disease usually causes, however, some permanent alteration in the hearing, though the amount is small in the properly treated cases.

The treatment of acute tympanic inflammation must be emphatically antiphlogistic. The endeavor must be to reduce the congestion and pain, and *to prevent suppuration*. The patient should be housed if the weather is cold or inclement in any way, and in most cases it will be best to confine the patient to a warm room. If the sufferer can be kept quiet and comfortable in bed, the sudorific treatment will be enhanced. The bowels should be opened by a saline cathartic if they are at all confined, and the perspiratory action of the skin promoted by the administration of sweet spirits of nitre, Dover's powder, neutral mixture, and the like. The pain should be controlled, if possible, by aconite—this drug having especial effect on the fifth and, perhaps, other cranial nerves. The one-tenth of a grain of the alcoholic extract of aconite (U. S. P.) may be administered every half hour or hour, according to the age and susceptibility of the patient. The sulphide of calcium, in doses of one-tenth of a grain every half hour or hour, has seemed in many instances to abort an acute inflammatory process in the ear, in adults. But care must be taken not to give too large doses, nor doses too long continued, as doses as high as two to four grains in twenty-four hours have deranged the bowels and kidneys, producing diarrhœa and strangury. The bromides in many cases will have a calming effect upon the nerves, and opium and morphia will aid greatly in easing the intense pain of acute inflammation of the middle ear. Combined with the constitutional treatment just detailed, local dry warmth may be employed. A hot-water rubber bag, or a flat six-ounce bottle, may be filled with hot water and kept against or in front of the auricle on the affected side. In many instances a sad-iron, a stone, or a brick, may be heated and wrapped in a piece of blanket and then kept close against the painful ear. These forms of dry heat should be tried before resorting to warm irrigations. If, however, in spite of all efforts made by the aforesaid methods for relief the pain increases, warm irrigations may be tried, either by the syringe or some form of aural douche, or by means of a piece of rubber tubing and a basin or pitcher of hot water, the two latter being arranged to work together by means of the siphon principle. A very simple and efficient way of applying hot water to the ear is by means of a spoon, dipping the water from a cup and filling the painful ear with hot water every few minutes, according to the temperature of the water and the feelings of the patient. If the inflammatory symptoms, however, increase, and the pain become more intense, the disease and the tendency to suppuration may be further combated by leeching. This is best accomplished by placing the leeches close to the ear. The points to which they should be made to attach themselves, are close in front of the tragus and along the limits of the auricle where it fades into the cheek.

If the pain and tenderness are marked in the region of the mastoid portion of the temporal bone, some of the leeches should be placed in the hollow close under the auricle, and over the mastoid. The so-called European or Swedish leeches will be found the best, because the largest and strongest. From three to six of such leeches will usually relieve the pain and check the advance of inflammation, if they are put on in time. From three to six ounces of blood should be drawn in the earliest stages of the disease.

If any of the products of inflammation have appeared, depletion by this means is most positively contraindicated; if blood is to be drawn, it must be done near the outset of the inflammation. Of course, this is a mode of treatment more easily carried out in a city and upon adults; but even children will submit rather than suffer.

Paracentesis of the Drum-head.—The drum-head should be frequently and carefully examined, and if the slightest bulging appears in it, or if the products of inflammation become visible through it, and it appears likely to be ruptured, it will be better for the surgeon to choose the place of opening than to leave it to nature. The best point for paracentesis of the drum-head has been found to be the postero-inferior quadrant, for from that point the tympanic cavity is most easily drained. Nature may rupture the drum-head at any point, but since perforations in the posterior parts of the membrana tympani heal more rapidly than those elsewhere in the membrane, and as perfect drainage of the drum-cavity is very important and most easily accomplished from below, it is best to select the point named, for incising the membrana tympani. But paracentesis is never to be resorted to simply to relieve pain. It should be performed only to permit the escape of the products of inflammation from the drum-cavity (p. 369).

All forms of continued poulticing should be most carefully and especially avoided in acute inflammation of the drum-cavity. In the first place, they cannot be brought into very close proximity with the diseased spot; and, secondly, in any event, they favor too great a maceration, and consequent formation of granulations in the ear. They are, therefore, especially evil in aural diseases, for the formation of granulations, brought about by a poultice to the ear, mechanically interferes with the escape of matter from the ear and inspection of the membrana tympani, and they may leave the organ chronically diseased, or destroy its functions altogether. This is the experience of every aurist, and is amply testified to in every modern work on Otology.

A kind of compromise may be made with the old prejudice in favor of poultices over the ear, by allowing the patient to wear a fold of cotton-wadding over the auricle and side of head, or to hold a warm hop-pillow to the painful ear. After secretion is established, a poultice of any kind would only increase the suppuration.

Simplicity of treatment added to a careful and thorough diagnosis, is the best means with which to combat acute disease in the ear, as well as elsewhere.

CHAPTER VI.

CHRONIC PURULENT INFLAMMATION.

When alluding to acute inflammation of the middle ear, the greatest stress was laid on preventing suppuration. If, in spite of all efforts, suppuration does occur, or if before the patient consults any one concerning his aural disease, suppuration shall have become established in the ear, then every endeavor must be made to check the discharge. There should be no fear to do this as promptly as possible, for so long as a chronic purulent discharge comes from an ear, the patient's life and hearing are in danger. There need be no anxiety therefore about "drying up" the running from the ear; "of driving it in on the brain," etc. Unhesitatingly it can be said that unless the otorrhœa is cured, the disease surely tends to extend to the brain. If it does not reach the brain, it may be because the patient will die of pyæmia and metastatic abscesses, before the central organ in the skull is reached.

Look at it then as one may, chronic discharge from the ear demands earnest consideration, careful and prompt treatment, and thorough cure, if it can be attained. So grave, in fact, is this disease that some insurance companies in Great Britain are advised by their medical examiners to refuse to take a risk on the life of one thus diseased.[1]

Often the hearing is gone, beyond hope of recovery, before any treatment of the purulent disease in the ear. At last the offensiveness of the running usually leads the patient to seek medical aid. The surgeon too often, after finding the hearing gone, advises the patient to let the discharge alone, "that it will dry up," etc. This is a mistake as fatal as it is common. Just because the hearing is destroyed, and the disease will advance from the middle ear to the internal ear, the mastoid cells, and the brain, the patient should be made aware of his condition and urged to undergo prompt treatment. His doctor should teach him that a disease which has destroyed the hearing can destroy the life; that cerebral abscess is but the logical sequence of such a corroding disease in the tympanum.

Treatment therefore should be instituted, not simply with a view of regaining the hearing, though often much is regained, but with the hope of freeing the patient from an offensive, annoying, and dangerous disease.

ETIOLOGY.

Respecting the causes of chronic purulent otitis media, it is almost enough to say that they are the same as those productive of acute otitis media, and that the latter is the forerunner of the chronic form. Briefly, they are exposure to cold, traumatic influences, diphtheria, and the exanthemata. The latter, especially measles and scarlatina, are notoriously assigned as causes of a large number of the cases of chronic purulent discharge from the ear, which the surgeon is called upon to treat. Most common of all assigned causes, is scarlet fever. The question naturally arises,

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[1] Dalby, Diseases and Injuries of the Ear, p. 176.

Is this necessarily the case; is there something in the scarlatinous poison which tends to eliminate itself through the mucous membrane of the middle ears? Can it for a moment be supposed that, just as the kidney is likely to become congested and inflamed in scarlet fever, so is the mucous lining of the ear? Since the throat and nasopharynx are very apt to be diseased in scarlatina, and since an aural disease is prompt to follow close upon a disease of the nares, the acute process in the middle ears, in scarlet fever, may be accounted for. But is there a specific tendency in the aural disease of scarlet fever, to become chronic? Upon close examination of these cases, it will be found that, though the sufferer has passed through a disease which has made him weak and liable to affections of the mucous tract, neglect of the acute inflammation in the ear has done the real mischief. Were this not true, then prompt attention to the inflamed ear in scarlatina would not be fraught with the good result it always is.

Diphtheria as a Cause.—Diphtheria is very often followed by a virulent form of chronic purulent inflammation of the ear, in children. There seems to be a tendency in this disease for the purulent otitis to fall at once into a chronic form. Pain is not always present and the acute stage is not well marked, but granulations spring up in a few days, the bone becomes necrotic, and sequestra are thrown off from various parts of the temporal bone. In a child sixteen months old, without any previous symptoms of pain or acute inflammation in the ear, a large cold abscess formed behind the auricle, pus ran from the meatus, the abscess was opened by the family's medical adviser, and denuded bone was found extending along the posterior wall of the external auditory canal and over the outer wall of the mastoid portion. In another instance, a little girl four years old was attacked by diphtheria; without any severe symptoms of acute otitis media, the child complained of discomfort in her right ear; then suddenly facial paralysis set in and continued for many days. This disappeared after a copious and fetid discharge from the meatus of the affected ear. Rapidly, without pain, an abscess formed over the mastoid and was opened, dead bone was found in the auditory canal and over the mastoid; the ear was blocked with large granulations, and the major portion of the mastoid was thrown off as a sequestrum, from the opening behind the auricle. The rapidity with which the chronic form of purulent otitis is established in these cases is worthy of note.

It is, therefore, advisable, in order to prevent destruction of the ear, to examine the organ in every case of diphtheria, especially if the patient's attention is called to the ear by the least discomfort, and, if it bulge, to make a free vent in the membrana tympani. This would permit the escape of matter from the drum, and prevent a burrowing to deeper parts. Such a procedure forms at least the best and perhaps the only means of preventing the rapid, almost gangrenous destruction of the ear, so likely to follow diphtheria in children. But ignorance of this fact, or unwillingness and inability to carry out the necessary manipulation in the examination and operation on the membrana tympani, have led the majority of physicians to underestimate the importance of doing that which is necessary to save the hearing and prevent necrosis of the temporal bone. Consequently the patient is said to have recovered from the diphtheritic disease, in cases in which he survives, but his hearing is lost, and he is spared only to undergo a tedious and exhausting suppuration in his ear, and finally to die from an extension of the aural inflammation to the brain, or to other organs of the body, or from general pyæmia.

In order to convince one's self of the fearful ravages of chronic purulent inflammation of the middle ear, it is only requisite to take a casual glance at the literature pertaining to otology in Europe and America. But, though many cases of these evil consequences are recorded, every one whose attention is specially drawn to the point, will state that numerous cases of death, from aural disease, are put down to other causes.

Age and sex have nothing to do with the causation of chronic purulent disease of the middle ear in children. The desire on the part of parents to have their girls free from the necessarily disgusting feature of an offensive aural discharge, leads them to bring their daughters sooner perhaps than their sons for treatment. Girls are more closely observed than boys, which accounts for the fact that among young patients the girls are in the majority. Boys, with a chronic aural discharge, are more likely to escape notice from the simple fact that they are absent from home more than the girls are. When, however, the boys begin to lag in their studies, on account of hardness of hearing, the aurist is consulted. Such circumstances may have more or less influence in causing an apparent preponderance in the number of young girl patients, over that of the young men, but one sex is just as liable as another to chronic purulent inflammation of the middle ear, in childhood. Of adult patients afflicted with chronic purulent otitis media, the men seem to be in the majority. This is accounted for in part by the above-mentioned want of care bestowed on them in boyhood, and subsequently by their more exposed life. Among the patients met with in infirmary practice, women, whose lives are exposed, as servants, are just as liable as men to contract chronic purulent disease of the middle ear.

SYMPTOMS.

The chief symptoms of chronic uncomplicated purulent otitis media, are either hardness of hearing, or profound deafness, and a purulent discharge from the ear.

The defect in hearing may vary from but slight hardness of hearing to absolute deafness. The vibrating tuning-fork on the vertex may be heard quite well in the affected ear if the labyrinth has not been invaded by the inflammation. If the latter has advanced inward toward the labyrinth, then the auditory nerve will have been more or less affected, and the failure to hear the tuning-fork, by bone-conduction, can be easily accounted for. While the deafness may be thus demonstrated to be absolute and irremediable, this fact is not sufficient to induce the physician to dissuade his patient from treatment, but rather to encourage him to undergo treatment, to prevent the advance of the disease.

The Discharge.—The discharge is usually much more copious in children than in adults. In the latter, the discharge is more likely to be copious the less chronic the disease, a feature due, in all probability, to the more active condition of the inflamed mucous membrane. As the disease advances, the mucous membrane is either destroyed, or so greatly altered in structure as to cease to throw off much secretion, and the discharge in such cases becomes thinner, more offensive, irritating, and suggestive of necrosed bone. In children the discharge is copious because of the activity of the mucous membrane of the nasopharynx, Eustachian tube, and middle ear. Hence, in these young patients the purulent discharge is mixed with ropes of mucus, more or less transparent, from the Eustachian tube and the tympanum. The color of the discharge varies from a light-yellow to a dark-yellow or green, but there is no rule about this. I have observed that the more copious discharges from children are lighter in color than the scanty, which are usually darker. The slighter discharges of adults, afflicted with chronic purulent disease of the middle ear, are dark and more likely to form crusts or scabs in the meatus. In some rare instances the color of an otorrhœa may be bluish, as mentioned by Dr. Zaufal.[1] Such a discharge was found to contain the bacterium termo; and the blue coloring matter gave a reaction characteristic of litmus.

In most cases there seems to be a peculiar butyric odor to the discharges of chronic suppuration from the ear. This is mainly on account of the want of cleanliness. There will be very little odor in an ear thus affected if it is kept clean and there is no necrosed bone retained. But if the latter provisions are not met, then of course all the peculiarly disagreeable and butyric odors of putrid pus and decaying bone will be emitted.

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[1] Archiv f. Ohrenh., Bd. vi. S. 206.

Appearances of the External Auditory Canal.—Inspection of the ear by means of the ear-mirror and the funnel will reveal maceration of the skin of the auditory canal, more or less destruction of the drum-head, and inflammation of the mucous membrane of the tympanic cavity. This is the view in an ordinary uncomplicated case; if there are complications arising from the purulent disease or from any other source, in the external or middle ear, they will now become apparent. But all such features of chronic purulent inflammation of the ear will be considered under the consequences of the unchecked disease. In order to obtain a good view of the external ear and membrana tympani, the auditory canal must be syringed out, and usually it will be found necessary to wipe off the drum-head with a little tuft of cotton-wool on the cotton-holder. This is demanded if the pus is tenacious or hardened on the remnant of the membrane. Syringing without the latter manipulation has often led to error, since the red and inflamed parts beneath the film of tenacious muco-pus have not been seen.

Inspection of the external auditory canal in the simplest form of chronic purulent inflammation of the middle ear, reveals maceration of the cutaneous lining of the passage, and sometimes one or more exostoses. The latter are the more likely to be found the more chronic the case. They rarely exceed two in number. If the chronic discharge is not copious, the maceration of the skin in the canal is not great. Instead of that, there are found scales and crusts of hardened pus, mucus, and epidermis in the inner part of the auditory canal and on the outer surface of the upper part of the drum-head. In cases of copious discharge, the delicate skin lining the inner part of the bony auditory canal, becomes more like mucous membrane than skin. This has led to the erroneous idea that the inner part of the auditory canal is normally lined with mucous membrane. It never is, but only assumes somewhat the appearance and nature of *diseased* mucous membrane, when subjected to constant irritation. This condition of the lining of the external auditory canal, is apt to be most marked in those individuals who have resorted to the injurious sponge-swab for cleansing their ears.

Appearances of the Drum-head and the Tympanic Cavity.—Chronic purulent discharge from the tympanum presupposes a perforation in the membrana tympani. Such a perforation may be at any point in the membrane, least frequently, however, in the flaccid part or the membrane of Shrapnell. A perforation in the membrana tympani may vary from the size of a pin's point to that which embraces the entire drum-head. Usually, even in the worst cases, a rim about the annulus is left, from which, if the purulent process is stayed, a new membrane may grow to a greater or less extent.

Multiple perforations are rare, sometimes two may be found close together in the under part of the membrane, separated by a thin band, and, in very rare instances, three perforations may be found in the same membrana tympani. The handle of the hammer may remain intact, notwithstanding large destruction in the drum-head. In other instances, the manubrium may be more or less eroded as the perforation extends. If the membrane is destroyed, or if the perforation in it is in the upper and hinder part, the lower portion of the long process of the incus, the incudo-stapedial joint, and the rami of the stapes, as well as the niche of the round window, may come into sight after the ear has been well cleansed of pus and then dried out with cotton on the holder.

Nevertheless, a large perforation may exist in the upper and hinder part of the membrana tympani, and the aforesaid ossicles may be intact, yet invisible, for they are apparently a little higher in the tympanum in some individuals than in others. The mere fact that they cannot be detected in cases generally favorable to their exposure, does not prove that they are destroyed. In some cases, the mucous membrane about them is too swollen to permit of their ready recognition. When a large perforation is about on the same plane with them, their lower ends may become visible by inclining the patient's head as far as possible towards the opposite shoulder, and looking up and behind the curtain-like rim of the membrana tympani, between them and the observer. In order to obtain a good view of the relations of these bones to one another, and of the separate rami of the stapes when they are to be seen, the patient's head will always have to be moved about gently from one position to another, till the desired view is obtained. The eye of the observer must always be directed towards the roof of the tympanum rather than towards the plane of the membrana tympani or inner wall of the tympanic cavity.

The appearance of the membrana tympani or its remnant, will vary from one of great opacity and grayness, with red and cicatrized edges of the perforation, to that of uniform redness and thickness. The manubrium of the malleus may be buried in the thick and swollen membrane, or, if the latter is gray and thickened, the position of the manubrium is marked often by only a tracery of congested vessels. In other cases, the handle of the hammer is seen as a ridge in the membrane of the same color, be that either red or gray: or, the handle of the malleus may project alone in the plane of the former membrana tympani. In such cases, the so-called folds of the membrane may still remain, extending from the short process of the malleus, one backward, the other forward towards the periphery. It is usually the posterior one which interferes with a good view of the deeper-lying ossicles. A perforated membrane is always retracted.

TREATMENT.

Two fundamental rules of treatment must be observed in every form of chronic purulent inflammation in the middle ear, viz., cleanliness and perseverance. In some cases it seems highly probable that careful and thorough syringing of the running ear, several times a day, persevered in, would have cured the disease without the aid of astringents. It would certainly be far better to rely on the use of tepid water and the syringe, with a good hope of success, than to do absolutely nothing for the inflamed and offensive ear, since, in the latter course, the condition of the ear and of the patient will almost surely go from bad to worse. Especially at the beginning of the scientific treatment should the ear be made clean by the surgeon, in order that its real condition should be seen, and then it should be kept clean in order that the remedies applied to the mucous membrane may have an effect. So important is this cleansing that it would be well to leave it entirely to the surgeon.

I have never found it necessary or desirable to employ any of the heroic methods of forcing water either through the meatus, the middle ear, and Eustachian tube, or *vice versa*. Saissy, Millingen, and Hinton have advocated this procedure for cleaning the middle ear of inspissated contents arising in chronic purulent inflammation. If, in syringing the ear, some water escapes into the Eustachian tube and throat, it is of no moment. It may, indeed, be a sign of more thorough cleansing of the middle ear; but it is not desirable to force water to take this course, for, at the same time, some of it might be injected into the mastoid cells and there set up acute inflammation. In any event, forcible syringing of the ear is very liable to make the patient dizzy. Moderate syringing will not thus affect the patient; it is usually borne perfectly. It is very unusual to observe a case in which no form or manner of syringing can be tolerated, on account of vertigo. Cleansing the ear in such an instance may be effected by using absorbent cotton on the cotton-holder. Sometimes, however, the most complete syringing will not remove all that should be washed out from the ear, especially the more tenacious variety of muco-purulent matter which collects like a film over the membrana tympani and the mucous membrane of the middle ear. In such cases, Castile soap may be added to the water, in sufficient amount to make the latter a little opalescent; or, before each regular syringing, a solution of bicarbonate of soda (10–20 gr. to f℥j) may be instilled into the ear and allowed to soak there from three to five minutes. Then, the matter thus softened may be more easily washed out. Still, in these cases, the surgeon must use his judgment as to whether the inspissated matter is to be removed or not. If the discharge is still active, then such masses should be removed; but if the running shows signs of stopping, it has seemed better in some cases not to wash these adherent films or crusts away. They do not invariably form, most discharges tending not to harden, but to come away if the ear is properly cleansed.

Not uncommonly, however, perforations in the drum-head close, first, by the formation of a kind of scab over the opening, then by true cicatricial tissue. The former finally falls off, leaving the latter as a permanent closure. But what I specially wish to call attention to is, *first*, the importance of favoring the formation of this scab-like closure in the perforated membrane of an ear affected with a chronic discharge from the tympanic cavity; and, *secondly*, the importance of letting such formations alone when they have once closed the perforation in the membrana tympani. Such formations must be regarded as an effort of Nature to protect the lining mucous membrane of the tympanum. The normal drum-head must be regarded, to a very great extent, as a barrier between a mucous surface and the direct effects of the external air.

It is often observed that as a discharge from the tympanum ceases, the matter now being poured out in small quantities from the hole in the membrana tympani begins to stick to the edges of the vent Nature provided it, until, at last, a small scab or plug fills the perforation and the discharge stops. The application of remedies, now, must be timed so as not to prevent this formation of a natural plug for the hole in the drum-head.

When a discharge begins to diminish, it is decidedly better to lessen the quantity of remedial applications to the ear; for they will not only prevent the healing or scabbing over of the perforation, but they will enter the tympanum, where they have ceased to be needed, and act as irritants. Doubtless, many discharges are kept up by continuing to syringe the ear and to put in drops. But no positive law on this point can be laid down. Each case must be studied pretty much for itself.

It will, however, never be amiss to pause in the instillations in order to find out whether there is really any further need for them, and to discover that which is still more important, viz., whether they are so far irritants as to keep up the slight discharge which still lingers.

Cessation of treatment is not unfrequently followed by formation of the above-named covering over the perforation, and the healing of the ear. That this covering of yellow inspissated muco-purulent matter over the hole in the drum-head is of greatest value, is seen in those cases in which it has been unfortunately removed.

In several instances where such a covering had formed, before the cases came under my notice, and before I was aware of the real meaning and value of this natural patch to the wounded drum-head, in my zeal to remove what in one sense was a foreign body, from the membrana tympani, I softened the scab and removed it. In two instances a clean-cut perforation became visible, and through it the healthy mucous lining of the tympanic cavity could be seen. But in a few days the mucous lining of the drum became congested, because the air had too free access to it, and an otorrhœa, which had subsided, returned.

After a longer or shorter period these dry coverings will peel off and escape as tough or hard shells, as the parts beneath heal and can dispense with them. This fact naturally drew my attention to the value of a dry local treatment in chronic otorrhœa.

The Advantages of a Dry Local Treatment.—One of the greatest hinderances to cure in an ear disease accompanied by otorrhœa, whether the disease be due to inflammation in the auditory canal or middle ear, is the presence of granulations and polypoid growths. Yet one of the oldest forms of treatment of otorrhœal disease has been by copious syringing and instillation of various fluid medicines. Hence, in such treatment of this class of aural diseases, moisture has been repeatedly applied to, and kept in the ear, a naturally heated locality. Now as heat and moisture tend to promote granulations and keep up a discharge, it has become very apparent to aurists that a moist treatment of otorrhœa in many instances has a tendency to keep up rather than to check the morbid discharge from the ear.

Cleanliness in a running ear must, of course, be maintained by judicious syringing with tepid water in copious discharges, and in cases of slight otorrhœa the ear can be kept clean without syringing by the use of a swab of absorbent cotton on the cotton-holder, or by absorbent cotton rolled into a long slender dossil, and gently inserted into the ear. A copious discharge may be defined as one which overflows the auditory canal, fills the concha, and runs on the cheek. A slight one just fills the canal as far as the meatus at most, or at least only keeps the membrana tympani moist. In the worst cases of otorrhœa I have long since ceased to let the patient or his friends syringe the running ear, if he can be seen every day or two by his physician, and let the latter perform this important operation. After syringing, the surgeon should dry the ear with absorbent cotton on the cotton-holder, applied under illumination of the ear by the forehead-mirror. If the patient must be entrusted with cleansing his ear at home, it should be done by absorbent cotton and *not with the syringe.* By following these general rules, it will be seen that a great deal of moisture once entering into the cleansing part of the treatment of aural discharge may be eliminated. Perhaps in one case in a hundred the patient's ear must be syringed at home, but not in a greater ratio of cases will the necessity arise.

Respecting the local medication of the diseased ear much may be said. Formerly a patient with otorrhœa, regardless of its cause, was directed, in addition to using the syringe several times a day, to put drops of various astringent solutions into his ear. The patient usually syringed his ear, or had it syringed, three or four times daily, and afterwards from five to ten drops of the astringent solutions were put into the meatus and allowed to find their way to the depths of the ear. This method, in many cases, seemed to do no harm, but to effect a cure, after a rather lengthy treatment, if no granulations sprang up, and if the fluid applications were skilfully diminished as the discharge decreased. If, however, at the first signs of decrease in the morbid discharge, the quantity of fluid treatment was not lessened, and this lessening was not kept up *pari passu* with the cessation of the discharge, the writer has often observed a steady increase in otorrhœa after a short but marked abatement. In other words, this kind of treatment after a longer or a shorter time may cease to act as a curative and begin to be a positive irritant, and hence to maintain the morbid secretion. Then, too, in the case of zinc drops, there seems to be supplied something which makes the fundus of the auditory canal favorable to the growth of the ear-fungus, the aspergillus. Zinc solutions, as prepared for the ear, certainly favor the growth of a fungus, looking something like aspergillus, at the bottom of the bottles containing them, very soon after they are brought from the shops, and in this may be found the explanation of their sometimes apparent fungus-fostering action in aural disease.

The syringe, therefore, and all forms of drops, as a rule, should be omitted from the home treatment by the patient in cases of otorrhœa. The most the patient should be directed to do is to dry his ear according to its need, by running into the canal and down to the fundus a twisted pencil of absorbent cotton. The patient in the case of copious discharge should see his physician every day at first, then every other day, and so on at longer intervals as the discharge diminishes. The surgeon is to use the syringe only when it is absolutely necessary to remove by it the matter from the ear, and thus prepare the organ for the application of medication by his hand. This latter part of the treatment should consist in the blowing of powders into the ear. Powders as the chief treatment, the dry treatment *par excellence*, have gradually come into use in the treatment of aural diseases characterized by discharge from the meatus, since Bezold, of Munich, recommended the use of boracic acid in powdered form for treating otorrhœa. In this country Sexton in New York, Theobald in Baltimore, and Todd and Spencer in St. Louis, have been among the earliest to give prominence to this method of treating otorrhœa, and to abandon the excessive use of the syringe.

These observers have used in powder, boracic acid and borax chiefly, perfectly soluble powders; and no other kind should be introduced into the auditory canal. Todd prefers in most cases powdered borax. Sexton has recommended a formula for boracic acid powder, which seems to me a highly useful one. (See p. 318.) In my experience this latter powder possesses unusual advantages in checking the discharge. Other powders possess also undoubted advantages, as for example one composed of—

Resorcin, ʒj.
Boracic acid, ℥j.

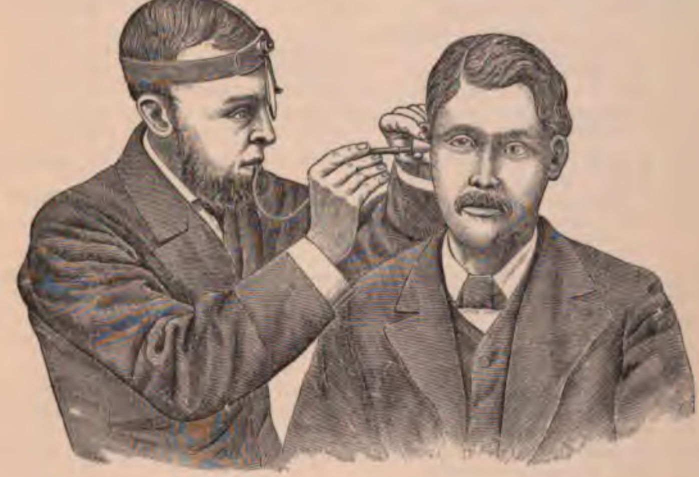
and also one which I have lately introduced to the notice of my colleagues, composed of—

Salicylate of chinoline, ʒss- ʒj.
Boracic acid, ℥j.

or the chinoline salicylate, an amorphous white powder, may be used pure. It is, however, likely to burn and cause pain when used in the latter state. In most cases it must be used mixed with sixteen times its weight of boracic acid before it can be endured in the ear. But its power of destroying bacteria is so great as to render it a most valuable aid in the treatment of purulent diseases of the ear, and in inflammation of the canal from the growth of aspergillus, for it kills the latter most promptly. In fact the excellence which all the powders named possess as healers of aural inflammation and discharge, while partially due to their drying and detergent qualities, is greatly augmented by their antiseptic nature. All powders should be blown gently into the ear by means of a very simple instrument, which the surgeon can make for himself. (See p. 261.) This method of insufflation of powders into the ear is shown in Fig. 92.

This is such a simple and perfectly efficient operation that the wonder is that it has not been sooner and more widely in use. It is still more amazing that the practicability of this manœuvre has been questioned, and that it has been recommended to resort to a clumsy and almost impracticable method of pouring and ramming the powder into the meatus and down the auditory canal, a method attended surely with loss of time and usually with failure. If persevered in with any roughness —and it can hardly fail to abrade and bruise the ear in any case—it will be followed by more or less acute inflammation of the canal.

Fig. 92.



The practical curative advantages of the treatment by means of insufflations of powders, over the treatment of otorrhœa by syringing and "drops," may be seen best by comparing the annexed tables of, in all, forty-five cases. The first fifteen cases show the results of the old method; the other two sets, fifteen cases each, show the advantages of the new or dry method of treatment by means of powders blown into the auditory canal. These have been taken arbitrarily from my note-book of *consecutive* cases.

TABLE I.—*Fifteen consecutive cases of Otorrhœa, as treated ten years ago by the "moist" method,* i. e., *by syringing and "drops," showing the great disadvantages of such treatment as compared with the dry or antiseptic method now more in vogue. Compare with Table II.*

			Days.	Result.
Case 1.	Woman, 30 years old, chronic.	1st period of treatment,	30	Cured.
	Relapsed in six months.	2d " "	330	Not cured.
Case 2.	Man, 30 years old, chronic.	1st " "	54	Improved.
	Relapsed in one month.	2d " "	73	Not cured.
Case 3.	Woman, 26 years old, chronic, both ears.	Under treatment,	120	Cured.
Case 4.	Girl, 13 years old, chronic.	Under treatment,	103	"
Case 5.	Girl, 18 years old, chronic.	1st period of treatment,	59	"
	Relapsed in four months by accidental entrance of cold water into ear.	2d period of treatment,	365	"
Case 6.	Man, 25 years old, chronic.	Under treatment,	207	Improved.
Case 7.	Woman, 40 years old, chronic, both ears.	Under treatment,	116	Cured.
	Had relapsed several times in ten years, with heavy colds, in head. Last relapse treated by "dry" method, and recovered rapidly.			
Case 8.	Man, 28 years old, chronic.	Under treatment,	195	Not cured.
Case 9.	Man, 17 years old, chronic.	1st period of treatment,	38	Cured.
	In a year took cold and relapsed (mastoid symptoms).			
	" " " "	2d period of treatment,	145	"
	" " " "	3d " "	61	"
	" " " "	4th " "	175	"
Case 10.	Man, 22 years old, chronic.	Under treatment,	30	Not cured.
Case 11.	Man, 18 years old, chronic.	" "	365	Improved.
Case 12.	Man, 30 years old, acute.	" "	17	Cured.
Case 13.	Woman, 19 years old, chronic.	" "	610	Improved.
Case 14.	Boy, 10 years old, chronic.	" "	44	"
Case 15.	Boy, 8 years old, chronic, both ears,	" "	45	Cured.
			3182	
	Average duration of treatment of a case by the old method,		212 days.	

TABLE II.—*Fifteen consecutive cases of Otorrhœa, treated by the "dry method," eighteen months ago, showing great advantages of the "dry" over the "moist" treatment.*

				Days.	Result.
Case 1.	Girl,	17 years old, subacute.	Under treatment,	15	Cured.
Case 2.	Girl,	4 " " chronic.	" "	1	"
Case 3.	Man,	38 " " "	" "	10	"
Case 4.	Boy,	10 " " subacute.	" "	4	"
Case 5.	Woman,	21 " " chronic.	" "	10	"
Case 6.	Woman,	45 " " "	" "	20	"
Case 7.	Boy,	3 " " "	" "	31	"
Case 8.	Woman,	27 " " "	" "	28	"
Case 9.	Boy,	10 " " "	" "	21	"
Case 10.	Girl,	4 " " "	" "	22	"
	(This case had a short relapse of a week, but was cured in two applications of boracic acid in powder.)				
Case 11.	Woman,	30 years old, chronic.	Under treatment,	4	Cured.
Case 12.	Man,	22 " " "	" "	66	Much improved.
Case 13.	Boy,	17 " " "	" "	13	Cured.
Case 14.	Man,	46 " " " (both ears)	" "	15	"
Case 15.	Woman,	35 " " "	" "	7	"
				267	
	Average duration of treatment of a case by this method,			17 to 18 days.	

This gives for an individual, in Table I., a treatment lasting 212 days, or, if estimated by occasions or periods, one lasting 151 days.

So far (July, 1884), the cases in Table II. have not relapsed, as many did under the old treatment, as shown in Table I. Table II. shows very plainly that a cure can be brought about in a very much shorter time than it ever was by the method set forth in Table I., and also that even when a short relapse does occur in Table II., as in Case 10, the second cure is more speedily effected than by the old methods of Table I.

The durability of a cure under the new method may be better seen in Table III., in which all the cases precede chronologically those in Table II. So far the cases in Table III. have held good, with the exception of Case 12, in which a short relapse has occurred, but which was speedily cured.

TABLE III.—*Fifteen consecutive cases of chronic Otorrhœa, preceding those in Table II., but treated also by the dry method, showing the less liability to relapse after this treatment.*

			Days.	Result.
Case 1.	Woman, 47 yrs., chronic 43 yrs.	Under treatment,	24	Cured.
Case 2.	Boy, 9 yrs. (a mute), chr. 5 yrs.	" "	90	Improved.
Case 3.	Boy, 10 " " " 10 yrs.	" "	90	"
Case 4.	Girl, 18 years, chronic 14 yrs.	" "	31	Cured.
Case 5.	Girl, 5 years, acute	" "	23	"
Case 6.	Girl, 7 years, chronic 5 yrs.	" "	60	"
Case 7.	Man, 25 yrs. (both ears), chr. 3 yrs.	" "	3	Withdrew impr'd.
Case 8.	Boy, 17 years, chronic 1 year.	" "	39	Cured.
Case 9.	Woman (negress), 30 years (granulations) acute.	Under treatment,	7	"
Case 10.	Man, 55 years, chronic 4 years.	" "	6	"
Case 11.	Woman, 35 yrs., duration not known (granulations).	Under treatment,	7	Much improved.
Case 12.	Man, 72 years, chronic 70 years (granulations)	Under treatment,	26	Cured.
	Short relapse in six months.	" "	2	"
Case 13.	Woman, 50 yrs. chronic since childhood. In this case the treatment had to contend with general cachexia, furunculosis meatus, dental caries, insanity in family, and *res angustæ domi* in a sensitive organization.	" "	73	"
Case 14.	Woman, 55 years, chronic one month (granulations).	Under treatment,	15	Cured.
Case 15.	Man, 38 years, chronic otitis externa at drum-membrane, with polyp.	Under treatment,	20	"
			516	
	Average duration of treatment of a case by this method,		34 to 35 days.	

This average is greatly increased by 180 days devoted to the treatment of the two mutes, Cases 2 and 3. But they must be counted in, as they enter the consecutive series.

Sometimes, however, it may be necessary to use fluid remedies in chronic aural discharges, if the perforation in the membrana tympani is small, in order to medicate the drum-cavity more thoroughly than can be done with a powder. The following solutions are therefore suggested.

The Chief Fluid Remedies to Check the Chronic Discharge.—Solutions of zinc, preferably of the sulphate, though the acetate is also very good, should be used in the strength of from one to five grains to the fluidounce of water. Only in the rarest instances will any advantage be derived from increasing their strength beyond this point. If they are thus concentrated, the discharges are curdled, the ear is blocked up, and the fresh secretion retained.

Solutions of nitrate of silver are useless in checking a chronic discharge from the ear, unless used in considerable strength. The most efficient are those ranging from 30 to 100 grains to the fluidounce; and not uncommonly saturated solutions (480 gr. to f℥j) are instilled not only without injury, but with positive good, as shown by Dr. Pomeroy.[1] The solid stick should *never* be used.

Prof. Schwartze[2] was the first to draw the attention of the profession to the use of strong solutions of nitrate of silver; he considered at that time those of 15 grains the weakest, and of 40 grains the strongest; latterly he has used much stronger solutions. It is not necessary to wash out the ear with salt and water after the application of the solution of silver. I think that caution demands careful consideration before very strong solutions of silver are instilled into the middle ear in chronic purulent otitis media, simply for fear of implicating the facial nerve. Though I have never met with such an accident, nor do I know of a reliable account of facial paralysis produced by the instillation of nitrate of silver into the tympanum, caution would forbid its use if there is any reason to suspect disease of the bone, for, if the latter exist, the Fallopian canal might be so far deficient as to permit some of the caustic to penetrate to the nerve. So long as there is reason to believe the chronic purulent inflammation has not advanced beyond the mucous tissues, there can be no harm in using strong solutions of nitrate of silver in the middle ear.

It is unadvisable to use instillations of solutions of nitrate of silver unless there is positive evidence of the absence of granulations on the exposed mucous membrane or upon the remnants of the membrana tympani, and unless there is entire absence of disease of the bone. If the discharge is predominantly of a mucous character, nitrate of silver may be used; if chiefly purulent, weak solutions of zinc and acetate of lead are to be used. Grossman,[3] as quoted by Schwartze,[4] advises the use of sulphate of zinc with catarrhal secretions, acetate of lead if the discharge is blennorrhœic and the perforation of the membrana tympani small, and crude alum in powder if the discharge is both blennorrhœic and copious and the perforations in the drum-head very large. I never employ alum alone for insufflation, since it produces otitis externa.

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[1] N. Y. Med. Journal, Dec. 1872.

[2] Archiv f. Ohrenh., Bd. iv. S. 1.

[3] Ungar. Med. Presse, 1870.

[4] Archiv f. Ohrenh., Bd. vi. S. 32, 1873.

Mode of Instilling Solutions of Nitrate of Silver.—The solution need not be warmed, as shown by Politzer, though Schwartze pursues an opposite plan. After the ear has been cleansed and dried, let an ordinary medicine-dropper be filled with the solution of silver, and then, with the head of the patient slightly inclined forward and toward the opposite shoulder, drop the caustic fluid into the meatus. If the Eustachian tube is pervious, Valsalva's or Politzer's inflation may be performed while the solution is in the meatus. Bubbles of air will rise through the fluid in the ear, and, upon ceasing the inflation, the solution will find its way still more readily into the tympanum and Eustachian tube. Such a distribution of the fluid is desirable, since an application is thus made to the Eustachian tube and nasopharynx, both of which are more than likely to be as much diseased as the tympanum in chronic purulent otitis media.

Schwartze has known an instillation of nitrate of silver to pass from the middle ear to the Eustachian tube and from the latter across the nasopharynx to the tube of the opposite ear, causing acute inflammation of the latter;[1] an accident which he further warns against lately,[2] since he believes it very likely to occur if the head is laid in a horizontal position during the instillation. Although he has assured himself of this possibility by experiments on the cadaver, his experience, so far as I am aware, is solitary.

The application of solutions of nitrate of silver, should never be entrusted to the patient or his attendants, for, if it be, there is every likelihood of staining his ear and cheek, and ruining his clothing. To properly apply a solution of nitrate of silver is somewhat laborious, and hence not likely to be carried out in the vast majority of cases, unless by a skilful hand. From motives of cleanliness it is well to put salt into the water with which the ear is washed after solutions of silver are used, since they are thus neutralized, and little or no staining of the ear occurs. Beyond this object, it is not necessary to neutralize the silver. But it is very obvious, that in a treatment which is more than likely to be tedious, every effort should be made to free the patient from the additional annoyance of black stains on his ear and his cheek, besides ruining his clothes and toweling. I have known patients to be justly indignant at having been advised to use an expensive solution, the entire nature of which they were unacquainted with until they discovered that, besides disfiguring their faces, they had ruined costly garments. Mothers who thus have been allowed to spoil their children's dresses, are not likely to be enthusiastic for a continuation of the use of silver, even when properly applied. Yet tucking a towel around the patient's neck and ear, be it child or adult, careful instillation of the silver solution, its momentary repose in the ear and its washing out with salt and water will prevent any annoyance. In the ear, as in every other part of the body, it is usually more important how a drug is used than what it is. The diseased mucous membrane of the middle ear is not very sensitive, so that the patient can be assured the drops of nitrate of silver will not pain him. This assurance will be not only comforting, but frequently demanded. The association of the names nitrate of silver and caustic will then cease to be as alarming as it often is, until the patient is reassured respecting his comfort. It must be stated, however, that if the skin of the external auditory canal is abraded in any way, nitrate of silver dropped into the ear will be for a moment acutely painful. But in such cases, the healing of these abraded cutaneous parts is brought about by the use of the silver, and there is no further pain. In the latter way may be explained the assertion on the part of some observers that nitrate of silver dropped into the middle ear causes pain, when in reality the pain is due to cauterization of an abraded spot in the delicate and highly sensitive skin in the inner part of the auditory canal. I have yet to see pain caused by contact of a solution of silver with the mucous membrane of a middle ear in a state of chronic purulent inflammation.

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[1] Archiv f. Ohrenh., Bd. iv. S. 233.

[2] Ibid., Bd. xi. S. 122.

Other Powdered Substances for Insufflation into the Ear.—Dr. Hinton has found powdered talc of great use in drying up a slight but persistent discharge; some have[1] recommended a powder of two parts of magnesia and one of salicylic acid in chronic purulent otitis media. This is certainly a most impalpable and beautiful form of applying salicylic acid. Dr. F. H. Rankin,[2] of New York City, has recently recommended the use of powdered iodoform in chronic purulent discharges from the ear. The peculiar odor, affecting some individuals really painfully, renders it objectionable as a means of treatment in private practice. It has never, so far as my experience goes, proven in the least degree irritating. Schwartze[3] recommends, as powders useful in checking slight chronic discharges from the ear, calomel, tannin, nitrate of bismuth, and magnesia usta.

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[1] Philadelphia Medical and Surgical Reporter, vol. 33, p. 103.

[2] New York Medical Journal, May, 1875.

[3] Archiv f. Ohrenheilkunde, Bd. xi. S. 123.

In the use of all the powders just named for insufflation the greatest watchfulness must be observed, in order to prevent concretions of the matters thus blown in.

Other Astringents used in Chronic Purulent Otitis Media.—Sulphate of copper, acetate of lead, aluminate of copper, nitrate of lead (von Troeltsch), and tannin in solutions are among the astringents which may prove of great benefit in some forms of chronic purulent inflammation of the middle ear. It will be observed in the vast majority of cases, the mineral are preferred to the vegetable astringents in the treatment of diseases of the ear. Tannin is rarely used, as it is regarded almost inert in checking a chronic purulent discharge from the ear.

Sulphate of copper is especially beneficial when the bone is diseased. It should be used in weak solutions (1–3 grs. to f℥j), as it is much more powerful than sulphate of zinc—*i. e.*, it will cause burning in the ear much more readily than the latter, if it is used in solutions of greater strength than just named. It was first recommended in aural diseases by Rau, and since, greatly lauded both by Lucæ and Schwartze. I have never found that the slight staining of the ear, which it sometimes produces, has materially interfered with the proper examination of the diseased parts. It is a valuable astringent, but irritating unless used in weak solutions.

Preparations of lead, though admirable astringents, are open to the same objections in treating diseases of the middle ear, as in diseases of the eye. The insoluble precipitates with albumen which they form have caused their almost total banishment from the treatment of chronic purulent otitis media. *Lead-water* has been used by Wilde, Schwartze, and Politzer, with asserted success, in checking suppuration from the ear.[1] But they are very cautious in its use, for fear of the aforesaid tendency of it to form, like other preparations of lead, insoluble precipitates.

Nitrate of lead has been recommended by von Troeltsch[2] as of some value in chronic purulent discharges from the middle ear, after other mild astringents have seemed to fail. I have used this preparation of lead in solutions of ten grains to f℥j, without perceiving any of the injurious effects of lead, and in some cases it has seemed of value as an astringent.

Other astringents, as aluminated copper (lapis divinus), sesquichloride of iron, chloride of zinc, sulphate of cadmium, and acetate of copper have been used to check chronic discharges from the ear. The greatest caution should be observed in the employment of solutions of iron in the ear. They are likely to mechanically obstruct the ear by rusty deposits, and thus to irritate and inflame the organ.

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[1] See paper by Schwartze, Archiv für Ohrenh., N. F., Bd. i. S. 34.

[2] Treatise, Roosa's translation, 1869, p. 461.

The course and consequences of unchecked chronic purulent otitis media are so common and so dreadful that it is proposed to devote the next chapter to their consideration.

CHAPTER VII.

COURSE AND CONSEQUENCES OF CHRONIC PURULENT INFLAMMATION OF THE MIDDLE EAR.

Without doubt, many of the bad results of chronic purulent otitis media are entirely due to bad treatment or neglect. The fatal issue so often seen is not a necessary one, if the disease had received even a fair amount of rational and intelligent treatment. This is amply proven by the statements of every one who has paid a little more than ordinary attention to the subject of aural disease. Doubtless, many more of the evil consequences of neglected otorrhœa would be recorded if they were even recognized as such. For, as every aurist knows, meningitis from an extension of an aural inflammation to the brain is by no means rare; yet the records are strikingly meagre, a fact only to be accounted for, either by ignorance on the part of the would-be diagnostician, or his unwillingness to acknowledge the cause and nature of the disease which has proven fatal while under his care. However, long before chronic purulent otitis media has reached its later and alarming stage, although some of its annoying consequences may have shown themselves, it is still curable if it is recognized and properly treated. In addition to the efforts to cure the original disease of the mucous membrane in the middle ear, other endeavors must be made to remove the evil consequences of this chronic inflammation which may have arisen.

Chronic purulent inflammation of the middle ear tends to the production of: 1. Permanent hardness of hearing and deafness. 2. Epileptiform and other nervous manifestations. 3. Granulations and polypi in the ear. 4. Ulceration of the mucous membrane of the tympanic cavity; periostitis; ostitis; caries and necrosis of any or all of the parts of the temporal bone and portions of the adjacent bones; inflammation of the meninges and sinuses of the brain; embolism; cerebral abscess; pyæmia and death.

1. Hardness of Hearing and Deafness.—Among the earliest consequences of chronic purulent otitis media, is destruction of the sound-conducting parts in the middle ear. This generally produces hardness of hearing and deafness, both of which are more or less permanent; though in some cases a surprising amount of hearing is regained under proper treatment. Usually, the perforation in the drum-head will close if the mucous lining of the tympanum is restored to health; but if the latter is not gained, or if the perforation of the drum-head be extensive and the ossicles have become carious, necrosed, and destroyed, a permanent diminution in hearing must be expected. The diminution of hearing and the extent of the loss in the membrana tympani and the ossicles do not seem to be in any fixed proportion. Sometimes it is found that a long-continued suppuration in the middle ear is accompanied by a small perforation in the membrana tympani, but that the deafness is great. Again, the perforation may be large and some of the ossicles deeply implicated, yet the hearing is by no means destroyed. In cases resembling the former type it is often found that bleeding and other evidences of granulations in the tympanum exist.

In the latter instances, though the sound-conducting parts are for the most part deeply diseased, the stapes and the mucous membrane round about its foot-plate and the oval window may be in a comparatively normal condition, which allows a free motion of this small ossicle in and out of the fenestra ovalis. At the same time it will be found that the membrane of the round window is intact, and that the delicate parts of the internal ear are therefore well protected.

With the two fenestræ thus in nearly a normal state, sound-waves are conducted by the stapes to the labyrinth. Should one or both of these fenestræ become diseased, or should the stirrup become impacted by swollen mucous tissue, in the oval window, then the hearing will be found greatly impaired.

Most cases of chronic suppuration in the middle ear have already undergone great loss of substance in the sound-conducting parts, long before a rational treatment has been instituted. Although at this point, by use of means already mentioned when considering the treatment of an uncomplicated case of chronic purulent otitis media, the discharge may be checked and the progress of the disease in the tympanum arrested, yet the hearing will usually be found greatly impaired, in consequence of a loss of substance in the sound-conducting parts and their failure in function. If the sound-perceiving parts, the labyrinth and its contents, are in a normal condition, an endeavor may in some cases be demanded and made to substitute the loss in the sound-conducting parts, or to help those portions which still remain, to convey sound-waves to the nerve of hearing in the labyrinth. This is best accomplished by some form of that instrument which is known as an artificial membrana tympani.

Artificial Membrana Tympani.—Contrivances to *protect* the middle ear in cases of perforation of the membrana tympani, were considered necessary and employed by Marcus Banzer, 1640, Leschevin, 1763, Autenreith, 1815, and Lincke, 1840. In one important sense, these devices were artificial drum-heads, because they were intended to supply the protective function of the natural membrane. They consisted mainly in short and delicate tubes, over one end of which a thin membrane was stretched and varnished, and then the instrument was worn in the auditory canal. But there is no good account of either an attempt to *improve* the hearing by their use, or that they even suggested the artificial membranes. In fact, they were considered as an impediment to hearing.[1]

As is well known, the first account of an artificial drum-head worn for the purpose of improving the hearing, is that of an American, who, of his own accord, thus used a spill of paper. He communicated his invention, and the good hearing he was able to gain for himself by its application, to Dr. Yearsley, of London, in 1841.[2]

The hint thus gained by Dr. Yearsley led him to try pellets of cotton instead of twisted paper, since a trial of the latter in other patients invariably failed. His success with cotton pellets, however, is universally known, and his method is used with great advantage at present, in a large number of cases, but with necessary modifications. The application, removal and renewal of the cotton pellet should be carried out by a skilled physician properly supplied with a forehead-mirror and delicate instruments, with the use of which he is thoroughly familiar, and after the cotton pellet has been successfully adjusted, it should be worn as long as possible by the patient, without removal or manipulation of any kind on his part. Another very important consideration in the successful use of cotton pellets is, that the ear must have ceased to discharge before they are introduced into it.

So far as my own experience is concerned, nothing but the cotton-pellet drum-head has ever produced any good results, unless I except the paper-disk drum-head of C. J. Blake; and this, having so many advantages akin to Yearsley's cotton pellet, has proven of value in my hands, and I believe it has an useful future. It will be referred to further on. My widest experience has been with the cotton pellet, and of this I wish to speak at this point.

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[1] Lincke's Sammlung, p. 182, I.

[2] See "Deafness Practically Illustrated," London, 1863, p. 221.

In 1863, Yearsley[1] formulated his experience with the cotton pellet. He omitted saying anything about the patients adjusting their own pellets, nor did he allude to the period a pellet, once well placed, might be worn. By implication he permits patients to introduce an artificial drum-head into their ears, and this also includes frequent adjustment of the same. Originally, from 1848 to 1853, he distinctly enjoins daily removal and renewal of the cotton pellet; but this has not seemed necessary nor desirable in all instances in my experience, and in proof of this I adduce the following case:

Josephine H., an English girl, aged sixteen years; going to school, but impeded in advancement in her studies by hardness of hearing in her right ear. Her mother stated (December, 1875) that she had been liable to attacks of earache, discharge of matter, and dulness of hearing on that side for some years.

An examination with ear-funnel and mirror revealed a chronic muco-purulent discharge from the tympanum, with a perforation in the lower and hinder quadrant of the membrana tympani, about two mm. in diameter. Hearing reduced to a few paces. Moderate syringing at home, and the use of drops of a solution of sulphate of zinc (3 gr. to f℥j water), checked the discharge in the course of a few weeks, but the hearing was not much improved. The mucous lining of the drum-cavity was still red, and looked raw; and in order to protect it from the winter weather then prevailing, I laid over the perforation a small pellet of cotton, with a diameter slightly greater than that of the perforation.

This improved the hearing greatly, and the pellet was allowed to remain over the perforation for some days. In the course of a week the cotton pellet was still in proper position, the hearing remained very good, and the ear felt more comfortable, *i. e.*, not tender on exposure to the open air. In the course of a few weeks, with a coryza, a little discharge came from the ear, washing away the artificial drum-head. But the inflammation was soon allayed as before, the discharge checked, and a cotton pellet applied again. I did not see the patient for some weeks, but when I did inspect her ear again the pellet was in proper position, the hearing was very good, and the membrana tympani around the cotton pellet looked dry and normal. Upon removing the cotton pellet the perforation was found to have grown smaller; another pellet was put over it, and the patient was not seen again for some weeks, when it was observed that the cotton pellet was in good position and the ear in every way doing well. Some months later the patient called again for inspection, when, upon removing the small pellet of cotton, which had been worn all the time of her absence from observation, the perforation was found to have entirely healed by a properly tense renewal of the membrane. And this good condition of the ear persisted for a year longer, after which time the patient was lost sight of.

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[1] London, 6th edition of his work on Deafness.

This case shows the very important and valuable functions of the permanent cotton pellet: 1. That it improved the hearing; and, 2. That while aiding the hearing it stimulated the closing of the perforation in the drum-head. And how simple the treatment!

This beneficial effect of prolonged wearing of cotton pellets I have seen in many other cases. It may, therefore, be concluded that when the membrana tympani is perforated, and the discharge from the tympanum has ceased, a cotton pellet will do more good when properly adjusted by the surgeon and let alone, than if manipulated every day; and that such artificial drum-membranes act both as temporary aids to hearing, and favor by protection, and, perhaps, by gentle stimulation, the healing of the chronically inflamed mucous membrane of the drum-cavity, and the closing of the perforation of the drum-head; though general improvement of the ear and hearing may ensue without the latter result.

Itard, Deleau, and Tod, are quoted by Toynbee, as having observed deafness relieved by the introduction of cotton or lint into the external auditory canal, and its contact with the partially destroyed membrana tympani.[1]

Mr. Wilde[2] stated that a lady informed him as early as 1845, that she had discovered that she could improve her defective hearing by inserting, down to the drum, a moist pellet of cotton.

Mr. Toynbee, in 1853, suggested the use of a disk of India-rubber, to the centre of which was fastened a silver wire by which the artificial membrana tympani could be inserted and adjusted.[3] But this, and all its modifications, I consider positive irritants.

Action of the Artificial Membrana Tympani—That the artificial membrana tympani greatly improves the hearing in many cases is amply shown by the experience of all aurists. How it acts in restoring the hearing has been variously explained. It may be by support, or support and pressure combined, as shown by Yearsley. The latter action would be required in cases in which there is no visible perforation, for Yearsley believed that the artificial membrana tympani was worn with improvement to the hearing in some cases of imperforate membrana tympani, as did Erhard, of Berlin. Von Troeltsch relates such a case too, of a judge whose hearing was improved by pressure on the imperforate membrane, but this action of the artificial membrane is considered doubtful by most authorities of the present day.

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[1] Op. cit., pp. 160, 161.

[2] Op. cit., p. 295. American edition, 1853.

[3] Op. cit., pp. 161–175.

If the hearing is ever improved by wearing any form of artificial membrana tympani against or pressed upon the imperforate natural membrane, it can only be explained as was done by Yearsley and Erhard, that, by an inflammation in the tympanum, the incus had become detached from the stapes, and the continuity of the chain of sound-conducting ossicles destroyed, without any accompanying perforation of the membrana tympani. Pressure now exerted upon the natural membrane, and mediately on the ossicles, might bring together the disunited incudo-stapedial joint, and sound-waves be again transmitted to the brain.

The artificial membrane probably does not act by merely stopping the perforation in the membrana tympani, thus confining the vibrations of sound to the tympanic cavity and concentrating them upon the labyrinth, as held by Toynbee.[1]

Moos,[2] Politzer,[3] and Lucæ[4] believe it to be shown that the benefits arising from the application of the artificial drum-membrane are due to intra-aural, *i. e.*, labyrinthine pressure.

Helmholtz, as quoted by Moos, supposes that, in cases in which the stapes is isolated from the rest of the chain, the artificial membrane takes the place of the natural one; or, as Politzer has expressed it, the artificial membrane, by virtue of its large surface, is able to convey to one of the ossicles a quantity of vibrations, which otherwise might be lost in their passage towards the labyrinth. Mr. Hinton[5] believed that "the question whether the artificial membrane operates by closing the orifice in the membrana tympani, or supporting the ossicula, and especially the stapes, is now decided in favor of the latter view," and accordingly, he made the endeavor to place the artificial drum-head in contact with the head of that bone.

Pressure may indeed be necessary in some instances to restore the hearing, especially if the stapes alone of all the ossicula is left and exposed by the great destruction of the membrana tympani.

But there are cases in which all the ossicula are present and vibratile, the stapes neither isolated from its fellows nor visible through the largely perforated and *greatly retracted* membrana tympani. Yet in these cases the proper application of an artificial membrane, especially of a cotton pellet, will improve the hearing. In such cases it is very plain that direct pressure on the already retracted drum-head and chain of ossicles would but increase the hardness of hearing, since the latter disturbance is doubtless due to too much labyrinthine pressure by the indrawing of the foot-plate of the stapes. The object of an artificial drum-head should be to overcome this undue retraction of the sound-conducting parts and take off the pressure from the contents of the labyrinth. An important function of the normal membrana tympani is to act as a partial antagonist to the tensor tympani. If this function is diminished, as it most undoubtedly is, if a portion of the membrane is lost and its tension overcome, the tensor acts with undue power, the ossicles are drawn inward, their proper swinging interfered with, and the labyrinth fluid unduly compressed. The cause of deafness is now very plain, and its remedy indicated in overcoming this retraction of the conducting chain. Therefore, if a pellet of cotton be so adjusted that its upper surface or periphery is gently tucked under the region of the tip of the manubrium, it will be found that the retraction is overcome, the chain of ossicles liberated, and the hearing improved.

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[1] Op. cit., p. 161, London, 1868.

[2] Archiv f. Ohrenh., Bd. i. S. 119, 1864.

[3] Wiener Med., Halle, 1864.

[4] Virchow's Archiv, Bd. 29.

[5] Op. cit., pp. 189, 190.

By bearing in mind that the ossicles of hearing are but a set of jointed bones, and that consequently their function depends upon neither disjunction nor ankylosis, an explanation is the more readily found for the failure in many cases, of pressure only, in the application of the artificial drum-membrane.

The Protective Function of the Artificial Membrana Tympani.—In addition to other good results, Yearsley[1] claimed that a pellet of moistened cotton-wool used as an artificial drum-head, would cure an aural discharge.

This function of the artificial membrana tympani is one that has been somewhat overlooked of late. Many an otorrhœa is kept up by the exposure of the tympanic mucous membrane beneath the drum-head, especially in those cases in which the inflammation has commenced in the latter structure. In such cases, by protecting the drum-cavity with a pellet of cotton laid over the perforation in the membrana tympani, a slight discharge which may not have shown any tendency to be checked will cease as soon as the drum-cavity is thus protected. If the perforation be not too chronic, such artificial protection will stimulate the edges of the perforation and favor a rapid closure. This is also well shown by the use of small paper disks, of sized paper, as first recommended by Dr. C. J. Blake, of Boston.

Respecting the application and results of these paper disks, Dr. Blake[2] writes me as follows:

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[1] Op. cit., p. 262.

[2] Boston, April 28, 1876.

"It consists in treating perforations of long standing, where the vibratory power of the membrana tympani and ossicula is not wholly impaired, by covering the opening with a piece or pieces of sized paper wet with water; the sizing gives sufficient adhesion. The applications generally improve the hearing immediately, and the paper stimulates new growth from the edges of the perforation, and protects it until repair is effected. The new growth, being protected by the paper, is firm and tense, and serves to assist in the vibration of the membrana tympani as a whole, as a lax cicatrix would not do. The paper is then removed by a natural process of repair and growth of the dermoid coat, which I am now making the subject of further experiment, showing a provision, as yet, so far as I am aware, undescribed, for the protection of the membrana tympani."

I have tried the use of such disks as Dr. Blake has recommended, and have found them of great service.

Gruber,[1] of Vienna, proposes to hasten the healing of perforations of the membrana tympani by applications to the hole of linen patches or of disks of sticking-plaster (English).

2. Epileptiform Manifestations and other Nervous Phenomena in consequence of Chronic Purulent Inflammation in the Middle Ear.—Chronic suppuration in the middle ear often gives rise to epileptiform manifestations and other nervous phenomena, as irritation of the chorda tympani and permanent facial paralysis, anomalies of taste, and disordered secretion of saliva, alterations in sense and sensibility of the tongue, *temporary* facial paralysis, alterations in gait, like those in Ménière's disease, or aural vertigo, softening of the ganglion of Gasser, with altered nutrition in the eye, and, perhaps, hemiplegia; but, gravest of all, reflex psychoses may be thus brought on.

The epileptiform manifestations occurring as a consequence of chronic suppuration of the middle ear, are to be regarded as reflex phenomena, due to pathological irritation of the sensory nerves of the ear. This is manifest from the record of cases made by Schwartze and Köppe,[2] Hughlings Jackson,[3] Moos,[4] and others.

The subjects of these attacks are usually young persons from 15 to 21 years of age, and so far as recorded, are observed to be of the male sex. The chronic suppuration had, in most cases, continued for a long period, was accompanied by repeated attacks of earache, the growth of granulations in the ear, large perforations in the membrana tympani, and foul discharges from the ear. In most of the cases, attacks of intense earache preceded the epileptiform seizure, and in one case, that given by Schwartze, there was precordial discomfort and a well-marked aura in the ear several hours before the fit. In this case, too, the headache was intense, but gradually located itself in the mastoid region, the gaze then became fixed, and twitchings in the region in front of the ear supplied by the facial nerve, would usher in unconsciousness. The predisposition to these attacks may last for several years and then disappear if the disease in the ear is lessened or removed. They occur in conjunction with chronic suppuration in one or in both ears. These seizures have been observed to occur first at night (Köppe and Hughlings Jackson), then in day-time; they come on at irregular intervals usually, though they may appear as often as two or three times daily, as observed by Köppe in an idiot boy in whom for ten years both ears had been seriously diseased after scarlatina. In the case of a boy, twelve years old, observed by Hughlings Jackson, a chronic discharge set in after scarlatina; nine months later facial palsy was noted, but this disappeared, and three months later, one year from the beginning of the aural disease, the first epileptoid seizures occurred at night. "It wakes him up, he feels giddy, he loses his sight, and does not know what he is doing. He then goes into the fit, struggles, and foams at the mouth; he does not bite his tongue; next day he is seemingly well."

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[1] Monatsschr. f. Ohrenh., No. 4, 1877.

[2] Archiv f. Ohrenh., Bd. v. S. 282, 1870-72.

[3] British Medical Journal, June 26, 1869.

[4] Archives of Oph. and Otol., vol. v., 1876.

Causes.—These epileptoid seizures may be due to minute changes in tracts in the brain which give rise to occasional discharges of nerve-force, as held by Hughlings Jackson. Although it is not known what cerebral region is affected, it may be found that these seizures are due to instability of those regions of the brain in which disease of the ear sometimes leads to abscess, a view also advanced by the same observer. One thing is very certain, that peripheral irritation in the ear is known to be the cause of a number of previously unrecognized reflex nervous phenomena. In some instances, the cause of the epileptoid symptoms has been supposed to be due to irritation of the tympanic plexus from inflammation in the tympanum, as shown by Moos. "This condition of irritation communicated itself to the brain and produced there the described attacks, which were favored by an hereditary tendency."

In some instances, epileptoid symptoms, or at least conditions of more or less sudden unconsciousness, occur in those affected with great nasopharyngeal catarrh and catarrh of the Eustachian tube, unattended with chronic purulent discharge from the tympanum. In such cases there are always evidences of increased swelling of the mucous membrane of the mouth of the tube, closure of the latter, and indrawing of the membrana tympani and the chain of ossicles. This, by carrying the foot-plate of the stapes further inward, causes increase of intra-labyrinthine and cerebro-spinal pressure, and the unconsciousness. If vomiting occurs, as in the case described by Moos, or if inflation of the tympana be effected, as in a case recorded by Erhard, the attack is ended, for the closure of the tube is overcome, in the first instance, by relaxation of the mucous tissues, and, in the second, by the mechanical effect of inflation, which draws the foot-plate of the stapes from the deep position in the oval window.

Treatment.—It is almost needless to say that the treatment should consist in the endeavor to remove the cause of irritation, especially if these seizures are to be regarded as reflex in origin. Hence, in Schwartze's case, recovery ensued upon trephining the mastoid; in Köppe's case by both constitutional and local means. Belladonna and a seton are classed by him under the first head, and under the second he places the treatment of the diseased mucous membrane in the ear. By this means the "vulnerability and reflex excitability" of the brain and the peripheral irritation are combated. In Moos's case the epileptiform symptoms were allayed by appropriate treatment of the mucous surfaces in the ear. Even reflex mental diseases may be cured by proper treatment of the middle ear and nasopharynx, and, in one instance, symptoms of intense headache, sensitiveness of the scalp, and the most melancholic psychical disturbances were entirely and almost immediately relieved by removing hardened blood-clots from each external auditory canal, where they had remained for years after a fall, in which hemorrhage into, if not from, the ear had occurred.

Various Nervous Phenomena produced by Chronic Purulent Otitis Media.—Chronic purulent disease of the middle ears may induce alterations of sense and sensibility in the tongue, as in a case related by Moos.[1] Since these phenomena were due to pressure on the diseased membrana tympani by an artificial membrane, and mediately on the chorda tympani, an important deduction may be drawn from this case, viz., that the chorda tympani contains and transmits not only fibres of taste, but also those of common sensibility. Dr. Carl[2] has described phenomena of altered sense of taste, occurring in himself, in consequence of chronic purulent otitis media, which were probably due to destruction of the chorda tympani.

The coincidence of *hemiplegia* with chronic and neglected suppuration of the middle ear has been pointed out in two cases by Roosa.[3] One case was that of a boy, ten years old; the other, a farmer, sixty-two years of age; though inclined to regard the former case as one of coincidence, it was regarded as probable "that a blood-clot might readily form between the dura mater and the bone, from rupture of the middle meningeal, in the existence of caries of the temporal bone, and hemiplegia be induced by pressure communicated to the motor tract, or, as Mr. Hutchinson says, as quoted by Hughlings Jackson,[1] by squeezing the blood from the corpus striatum or thalamus opticus."

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[1] Archives of Oph. and Otol., vol. i. pp. 140–148, 1869.
[2] Archiv f. Ohrenheilk., Band x. S. 152.
[3] Transact. Amer. Otol. Soc., vol. i. p. 118, 1870.

Paralysis of the Facial Nerve.—Paralysis of the facial nerve is not a common occurrence in chronic suppuration of the middle ear, but if it occurs with necrosis of the temporal bone it is very apt to be permanent. During chronic suppuration of the ear, however, temporary paralysis of the facial nerve may appear. Such attacks of palsy may be referred to temporary congestion and an acute inflammatory process in the middle ear, in addition to the already existing chronic disease. *Temporary palsies* of the parts supplied by the facial nerve occur in perfectly healthy ears which have become the seat of acute inflammation, and are probably due to congestion, especially in children, and to pressure of accumulated secretion, as shown by Gruber.[2] That such palsies may occur, and probably by an acute process, in a chronically suppurating ear, is shown in the following case:

The patient, a lad of fourteen years, stated that he had had a neglected aural disease ever since childhood. Some weeks previous to the time I first saw him, August, 1874, he had been attacked by severe pain in the left ear, after bathing in the sea, at Cape May, where he was employed. He then came to Philadelphia to obtain relief from the terrific pain in the ear, and applied to Dr. A. D. Hall, who made a deep incision over the mastoid process, giving vent to a large quantity of exceedingly offensive pus, and relieving greatly the suffering of the patient. The next day Dr. Hall sent the boy to me. I found the lad very weak and sallow, with a pulse over 100, forehead bathed with clammy perspiration, anorexia, less pain since the mastoid incision, with considerable vertigo, and an offensive purulent discharge from the ear and the incision over the mastoid process. I found that a probe entered over the mastoid process point-blank, three-fourths of an inch, coming in contact with denuded bone. There was also a sinus running from the external auditory meatus, upward and backward, to dead bone in the mastoid cavity. The patient stated that about a year previous to this time a piece of dead bone had worked its way from the auditory meatus, after an attack of pain in the ear. A probe, passed through the sinus in the auditory canal, and another passed through the sinus behind the auricle, could be made to touch each other in the mastoid cavity, and dead bone was felt everywhere in their path. The silver probe passing into the sinus running from the auditory meatus, became instantly blackened, and from this sinus crumbs of black and offensive bone were constantly discharged, for several days. At the point in the auditory meatus where the probe entered, there was a large bunch of granulations, which was finally removed by a wire-snare. I could not detect any sequestrum at that time. The boy was placed in the Presbyterian Hospital, and given milk-punch and tincture of chloride of iron thrice daily for several weeks, during which period the pain became very much less in the ear; that which he still experienced was above, and running forward from the auricle. The vertigo disappeared, and the patient was able to take muscular exercise; the ear became less tender, and permitted all necessary manipulation, but the patient could not lie on the ear in bed. Under this treatment the discharge grew less, and on the 24th of September I extracted, through the opening in the mastoid process, a spongy sequestrum one-half inch square, and then, placing the broad, blunt nozzle of a syringe in the opening, I gently injected a stream of warm water, which washed out a copious amount of large cheesy-looking masses through the external auditory meatus, and some portions of the mass, passing through the Eustachian tube, escaped by the mouth. The masses were composed of large acicular crystals of cholestearine and fatty epithelial débris, resembling the matter found in so-called cholesteatoma of the ear. The removal of the sequestrum and the subsequent syringing, with its fruitful results, gave still further relief to the patient; all pain disappeared, and he could now lie on the ear in bed.

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[1] Reynolds's System of Medicine, vol. ii. p. 505.

[2] M. f. O., No. 10, 1873.

The sinus behind the auricle closed in four days after the removal of the sequestrum, and in a week from that time the discharge from the ear had almost ceased, and the odor of diseased bone, which had pervaded the patient, had disappeared; but I could still feel *loose* crumbs of dead bone lying in the sinus leading from the auditory meatus to the mastoid cells. Therefore, the sinus was widened with a knife, by cutting from the meatus towards the mastoid process, and a tent was inserted in the thus widened opening. The tent was reinserted for five days; crumbling bone came away, the odor and discharge lessened, and the sinus in the meatus closed October 17, under instillations of a solution of sulphate of copper (3 gr. to f℥j). The patient had become by this time quite strong under the constant use of tincture of chloride of iron, and occasionally, alcoholic stimulants.

During the night of the 19th of October, four weeks after the removal of the mastoid sequestrum, the patient experienced some pain in the ear, but not enough to keep him awake. On the morning of the 20th, he found that "he could not whistle," and that the tears ran over his left cheek constantly. Facial paralysis became fully established on the left side by the 21st; so much so that food lodged between the cheek and teeth on the affected side. There was no continuance of pain, and the patient expressed himself as feeling very well. He took, without my consent, a situation offered to him, and went to work at this time, the paralysis disappearing in two weeks, as I learned subsequently, for I did not hear from him until nine months later, when he visited me, and I found him entirely free from paralysis and all aural discharge. He had continued, on his own responsibility, to take the tincture of the chloride of iron until the paralysis had disappeared.

Facial paralysis is not of frequent occurrence in necrosis of the mastoid process, but if it occurs it is likely to be permanent. Its permanence is due to the erosion of the Fallopian canal, and an organic lesion of the facial nerve. Its occurrence and subsequent disappearance in this case are of interest, and worthy of consideration. They can be explained, I think, as follows:

1. It is well known that the facial nerve will resist the chronic inflammation attacking the petrous bone, long after the Fallopian canal is destroyed. Gruber has reported a case in which the facial nerve was exposed for two-thirds of its length in the tympanum, by necrosis of the Fallopian canal, and yet no paralysis occurred at any time.

2. It is, therefore, probable that the facial nerve becoming unduly exposed, in the case I have described, by caries of the Fallopian canal, a slight acute inflammation in the middle ear furnished pressure sufficient to produce the functional paralysis. The disappearance of the paralysis was of course due to the absorption of the products of the acute inflammation, from which it may be learned that, alarming as paralysis of the facial nerve is in *necrosis of the mastoid cells*, the prognosis is not necessarily unfavorable, for it may be simply a temporary paralysis, due to pressure from an effusion of fluids, which can soon become absorbed and the nerve thus permitted to resume its function.

Alterations in Gait.—In connection with chronic suppuration of the middle ear and caries of the petrous bone, Dr. Tédonat[1] observed peculiar alterations in gait, by which the patient was made to pursue a curved line in walking, and, at the same time, was inclined to turn about his vertical axis from the affected towards the well side. There was at the same time facial paralysis, softening of the ganglion of Gasser, and altered nutrition in the eye. Post-mortem examination revealed destruction of the semicircular canals in this case.

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[1] Lyon Médical, No. 26, 1874; also abstract by Schwartze, A. f. O., Bd. x. S. 256.

Irritation of the Chorda Tympani.—Dr. H. D. Noyes[1] has given an account of irritation of the chorda tympani produced very probably by disease in the tympanum. The patient, a physician, 33 years old, stated that at the early age of one year and six months, he had an abscess in his ear, but exactly in what part of the organ he could not tell. A discharge was thereby established in his ear, attended with perforation of the membrana tympani, impaired hearing, and constant tinnitus aurium. This condition prevailed until the patient's twenty-third year, when the discharge became somewhat altered in its appearance, and subject to variations in amount. About this time the perforation in the membrana tympani is supposed by the patient to have closed. About the same time a feeling of "weight, pressure, of obstruction, and of distention affected the entire left side of the head." Not long after this the patient states that the chorda tympani nerve began to manifest symptoms of irritation. Morbid sensations of taste were easily excited by pinching the pinna, or by stroking the left side of the face with the tip of the finger. This phenomenon, at first paroxysmal, at last became permanent without any external exciting cause. The flow of saliva had been proportional to the amount of irritation. Large portions of it had come from Wharton's duct, but the left parotid gland also secreted more abundantly than the right. Latterly, that is about ten years after the supposed closure of the membrana tympani, facial paralysis was suddenly developed, and had remained constant.

When Dr. Noyes inspected this case, he found complete paralysis of the left side of the face, including the forehead and orbicularis oculi; the mouth was drawn to the opposite side; the tongue was protruded straight, and its mobility was perfect. The external auditory canal was large and straight, and the membrana tympani was nearly flat, tense, white, and thick, not vascular. Seated upon its upper and middle portion was a polypoid growth as large as a pea, firm to the touch, red, but not disposed to bleed. "*The slightest touch of it, though not painful, excited sensations in the tongue.*" The auditory canal contained a moderate amount of pus, the Eustachian tube was pervious, and the tympanum easily inflatable; hearing reduced to contact. The polypus was removed; the membrana tympani assumed an appearance which did not seem to indicate the presence of granulation-tissue in the drum-cavity, and there was no perforation. The discharge ceased, the hearing improved, and the disgreeable head-sensations disappeared. Dr. Noyes stated that the polypus sprang from the handle of the malleus, and his explanation of the peculiar symptoms of irritation, was that "this bone had been the seat of chronic inflammation, involving its substance and periosteum, and which had caused the irritation of the chorda tympani." That the cause of the irritation in this case was in the middle ear, as well as in the membrana tympani, is fully shown by the facial paralysis.

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[1] Transactions American Otological Society, vol. i. p. 556, 1875.

It must be borne in mind that the chorda tympani has no part in the nervous function of the tympanum; it is only on its way through the tympanum to the tongue (see p. 85). This nerve, or branch of the facial, if it be a branch of the latter, is, of course, liable to be injured by morbid processes in the tympanum, but it is in no physiological way connected with the functions of that cavity any more than the facial nerve is, as it passes through the Fallopian canal in the posterior part of the same cavity. In many respects the name chorda tympani is unfortunate, as it would naturally suggest a nerve of more than ordinary importance to the drum-cavity.

Anomalies of Taste and Salivary Secretion in Chronic Purulent Disease of the Tympanum.—The sense of taste, as well as the secretion of saliva may be altered, either diminished or increased, by the presence of chronic purulent disease in the cavity of the drum. Dr. Urbantschitsch[1] found, in an examination of fifty individuals affected with chronic purulent disease of the tympanum, that the sense of taste is most highly developed in the region of the posterior wall of the pharynx, the uvula, the arcus palato-glossus, the base of the tongue, and on the mucous membrane of the cheek. In forty-six individuals, anomalies of taste were discovered: only in four cases of purulent disease on one side was the sense of taste undisturbed, remaining equal on both sides. In thirty-eight cases the taste was diminished, three times abnormally increased; in five cases it was in some respects increased and in others diminished; thus in a case of chronic purulent disease in the right ear the sense of taste for salt and bitter substances was impaired, while it was augmented for sweets and acids. Besides these disturbances of taste, there was in twenty-four cases a blunted sense of touch; in six cases, though the sense of taste was lost on the affected side, the sense of touch was normal.

The causative effect of the purulent disease in the ear is confirmed by the fact that in many cases the anomalies of taste and touch vanished with the healing of the ear. The chorda tympani and the plexus tympanicus are to be looked to for the explanation of these changes. In addition to the above changes, anomalies in the secretion of saliva have also been noted by Dr. Urbantschitsch; in one instance where a polypus was situate near the upper part of the tympanum, and in other cases, after various powders had been blown into the ear, and the tympanum had been touched by nitrate of silver. In the first instance, the stimulation is supposed to have been brought about through irritation of the chorda tympani, and in the other cases by excitation of the lesser superior petrosal nerve, the influence of which over the parotid was distinctly and directly observed on a patient. These clinical observations of Dr. Urbantschitsch appear to be in harmony with the experiments of Cl. Bernard, Schiff, Ludwig, and others.

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[1] Ueber Anomalien der Geshmaksempfindungen der Speichel Secretion in Folge eitriger Erkrankung der Paukenhöhle, Gesellschaft d. Aerzte in Wien., 21 April, 1876. Wiener Med. Presse, No 23, 1876, M. f. O., No 10, 1876.

Vertigo in Chronic Purulent Disease of the Middle Ear.—It sometimes happens that well-marked symptoms of aural vertigo occur in chronic purulent disease of the middle ear. But I have not found this to be common. The following case will illustrate, however, its occurrence. A. B., age 18 years, student in classics, has had purulent disease of both ears from scarlatina in infancy. On the right side, the membrana tympani is destroyed and the hearing gone. The discharge has become very slight. On the right side, the membrane is perforated. The mucous membrane of the tympanum is thickened over the promontory. Hearing for moderate speech four paces. The discharge was slight on this side. January, 1877, the patient stated that a day or two previous, while in the lecture-room, he was suddenly seized as never before, with a roaring in the left ear, which was followed by nausea, dimness of vision, giddiness, and faintness, but he was able to leave the room unaided, and went home. While riding home the symptoms all vanished, and within fifteen minutes he felt quite well. In this case the lesion must have been in the middle ear, but the dizziness, etc., were probably due to an irritation extended to the labyrinth, from pressure by an over-accumulation of secretion in the tympanum.

Reflex Psychoses from Chronic Purulent Inflammation of the Middle Ear.—Quite recently, Köppe[1] published an account of two cases of reflex psychoses, in one of which the mental disorder was in all probability excited and kept up by chronic purulent otitis media. In the other case hardened blood-clots in each external auditory canal were very plainly the exciting cause of the insanity. In both of these men, though possessed of an hereditary tendency to insanity, and having been exposed to violence on the head, by falls and blows, the mental disorders, melancholia with tendency to murder and suicide, were entirely relieved by treatment applied to the ears and the chronically inflamed nares and nasopharynx.

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[1] Archiv f. Ohrenheilk., Bd. ix. S. 226, 1875.

3. Granulations and Polypi.—Purulent inflammation of the middle ear may lead rapidly to the formation of granulations and polypi. These results are, however, more likely to be found as a consequence of neglected and chronic suppuration of the tympanum. The former may appear quite soon after a purulent process has been established in the middle ear, and may be attached either to the mucous membrane of the tympanum, to the membrana tympani, or to the walls of the auditory canal.

Upon inspection of an ear in which granulations have sprung up, the view obtained will depend upon the size and quantity of these growths. When growing on the mucous membrane of the tympanic cavity, they will give to it a roughened and granular appearance, very readily seen if the perforation in the membrana tympani is large, and unobstructed by granulations. The latter may grow on the edges of, or near the perforation, on the mucous side of the drum-head. If granulations have also sprung up in the auditory canal, these may obstruct all further view of the membrana tympani and tympanic cavity. All granulations should be considered as incipient polypi.

Polypoid Hypertrophy of the Mucous Membrane of the Middle Ear.—Wendt[1] has described under this term, elevations of the muco-periosteal lining of the middle ear, which occur very frequently in exudative inflammations, and are characterized as exceedingly small polypi in their structure. In rare instances these prominences may assume a fold-like elevation, but more commonly these bodies possess a thread-like, or villous form, as well as a finger-shape. They may also be spherical or ovoid in shape, and are attached either by a long pedicle or by a broad strip to the mucous membrane. Sometimes they constitute extensive, lobulated masses. The size of these prominences and villi is very varied, reaching in the larger ones a size of 1 mm. According to their composition, these prominences are shown to be proliferations of the subepithelial layer of mucous membrane. A direct participation in them of the periosteal layer could not be found, nor could a corresponding elevation in it be detected. In the spaces between the network of connective tissue, numerous cells resembling lymph-corpuscles were found. The epithelium was sometimes cubical, and, in some instances, cylindrical, both kinds often being found in the same microscopic section.

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[1] Review by von Troeltsch, Archiv f. Ohrenheilkunde, Bd. ix. S. 119.

The same kind of miniature polypi were found on the inner surface of the membrana tympani by Wendt.

The mucous membrane of the tympanic cavity is in any case predisposed to hyperplastic processes, and to the formation of rugous elevations and firm projections. By continued growth and constant enlargement these formations may entirely fill up the tympanum, and, after perforation of the membrana tympani, fill the entire auditory canal. They may also cause flat, bridge-like adhesions to form between the membrana tympani, auditory ossicles, and the walls of the tympanic cavity. Cystic cavities may be formed by the union of several elevations with one another. By degeneration and exfoliation these polypoid growths may disappear. Spontaneous degeneration is brought about in these cases by deposition of fat, or by hemorrhages; the vascularity of these growths greatly predisposes to the latter mode.

The pathological alterations in the veins and lymphatics of the mucous membrane of the tympanum, in cases of chronic purulent discharge with perforation of the membrana tympani, have been described by Politzer.[1] These changes chiefly consist in dilatation. In some instances the veins, especially on the inner surface of the mucous membrane, covering the promontory, are greatly widened, very tortuous, with here and there large dilatations. He concludes that in chronic inflammation of the lining of the drum-cavity, large numbers of new vessels are formed. The walls of the bloodvessels are often opaque and thickened, being infiltrated with a granular exudation, and pigmented; or, in other cases, the vessels may be filled with blood-globules, while the walls are thinned at some points, and consequently dilated here and there.

The changes in the lymphatics of the mucous membrane of the tympanum are much less common than the alterations in the bloodvessels. Altered lymphatics have been found by Politzer in new connective-tissue growths in the cavity of the drum, when affected by chronic purulent inflammation.

Treatment of Granulations.—Since granulations are very often the result of poulticing in the acute stage of an inflammation in the ear, it should be said again that all such treatment as contains any of the elements of heated moisture, must be avoided in the endeavors to cure granulations in any part of the ear. The ear should be kept scrupulously clean by syringing, to be repeated as often as is necessary to gain this object. Then some form of astringent or caustic should be applied. An endeavor may also be made to remove, by evulsion, the large granulations, if they can be gotten hold of with convenience to the surgeon and without pain to the patient. But it is not absolutely necessary thus to remove granulations from the ear. They may be pencilled with solutions of nitrate of silver (60–480 gr. to f℥j) or with chromic acid. These applications are best made by means of a small tuft of cotton on the cotton-holder; great care should be taken to have not too much of these fluids on the cotton, but just enough to paint the growths without causing any surplus of fluid to be squeezed out and run upon other parts of the ear, as soon as the cotton-tuft is brought into contact with the granulations.

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[1] Studien über Gefässveränderung in der erkrankten Mittelohrauskleidung, A. f. O., N. F., Bd. i. S. 11.

Aural Polypi.—The term polypus is a relic of the older nomenclature, which classed new growths according to their form or general appearance, rather than their structure. The name polypus was first applied to all tumors which, originating by means of a distinct pedicle from the inner surface of any cavity of the body, projected at last as an independent growth into the same, or into the passages leading to it.

AURAL POLYPI.

Aural polypi vary in size from one millimetre to three or four centimetres in length, and may completely block the external auditory canal, and project beyond the meatus. They have generally a more or less club- or pear-like shape, and their surface is usually papillated, giving a mulberry-like appearance, particularly to the basal portions of the growths. With few exceptions their consistence is soft, but elastic, and their color may be any shade of grayish-pink or red.

Aural polypi are frequently multiple, several of them being found in the same ear. One or more of the auditory ossicles may become embedded within the substance of one of these growths, and the tumor may also by its pressure markedly enlarge the osseous part of the auditory canal. These aural tumors may originate from the mucous membrane or periosteum of any portion of the tympanic cavity, or, much more rarely, from the dermoid layer of the membrana tympani, or the skin of the external auditory canal. By far their most frequent seats are on the upper and inner walls of the tympanic cavity.

Polypi are most frequently found in males, and before thirty years of age. The vast majority occur in cases of suppurative disease of the middle ear, and when they are situated on the wall of the external canal, it will be generally found that the suppurative process has been a very prolonged one. In fact, all these growths may be considered as inflammation-tumors, distinctly illustrating the now widely accepted doctrine of the inflammatory origin of all neoplasms.

By far the larger number of aural polypi are covered with epithelium, the character of which always agrees with that of the cells covering the mucous membrane from which they have originated: thus if from the floor of the tympanum or the lower portion of its walls, the epithelium will be columnar or columnar-ciliated; while if from the promontory or the roof, it will be found to be of the tessellated variety. The transition from the former to the latter of these forms in the tympanum is gradual, and thus it is that several varieties are, in rare instances, found upon the same polypus.

In systematic treatises upon diseases of the ear, aural polypi have long been classed into mucous polypi, fibromata, and myxomata; angiomata having lately been added to the list by A. H. Buck.

The term mucous polyp has only a clinical meaning, every form of tumor of *soft consistence* found in the ear having been described by different authors under this head.

The statements of Schwartze[1] and others that this form of growth exactly resembles the mucous polyp of the nasal and other cavities, is absolutely incorrect, the mucous polypus of rhinologists being simply a hyperplasia of the normal mucous membrane, and no such growth has yet been accurately described as occurring in the ear. The name, therefore, should be permanently dropped from otological literature, or used only in a clinical sense, to denote any tumor of *soft consistence.*

Moos and Steinbrügge,[2] in their very valuable paper on this subject, call most aural polypi "granulation-tumors," and the name is a most satisfactory one, but they seem to overlook marked differences in the structure of the neoplasms classed under that heading, and to ignore the similarity or identity of many of them, to soft or mucous papillomata. Aural polypi should be classified as follows: 1. *Granulation-tumors;* 2. *Soft Papillomata;* 3. *Fibromata;* 4. *Myxomata.* In the rearrangement of the section on aural polypi, and the classification he has now adopted, the author has been greatly aided by the investigations of Drs. R. W. Seiss and Walter Chrystie, of Philadelphia.

Granulation-tumors (see Fig. 93) are usually of small size, very dark in color, of soft consistence, and bleed easily and freely when touched. They comprise about one-half the entire number of aural polypi, and are usually found in cases where the suppurative process has been rapid and intense. Their structure is that of a simple granulation, from which they markedly differ, however, in being covered either by a layer of columnar or squamous epithelial cells, the latter of which may form a dense, horny coating to the growth.

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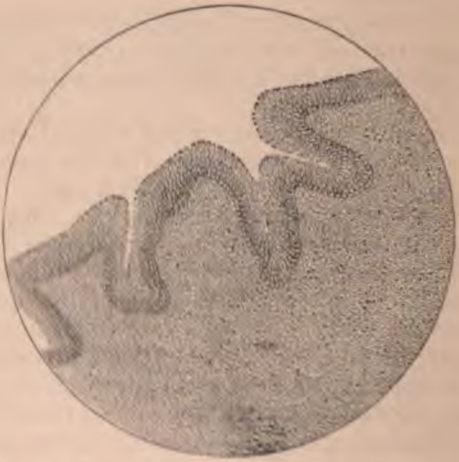
[1] Pathological Anatomy of the Ear, p. 125.

[2] Archives of Otology, vol. xi. p. 328.

They consist of spherical embryonal cells, some of which present very distinct nuclei, others having several very small nuclei. Among these elements are numerous capillaries in an embryonal condition. Some of the embryonal cells send out prolongations, which unite by anastomosis with others, and thus a network of plasmatic cells is formed, the meshes of which are filled with an amorphous, fundamental substance, sometimes fibrillar, in which are held the spherical embryonal cells. These polypi are frequently deeply stained with blood, or large clots may be found, from ruptured bloodvessels in their substance. The epithelial covering may occur in single or in multiple layers, and may, as already stated, consist of columnar or of squamous cells. It adheres firmly to the stroma of the growth, following all the convolutions of the lobulated surface.

Fig. 93.

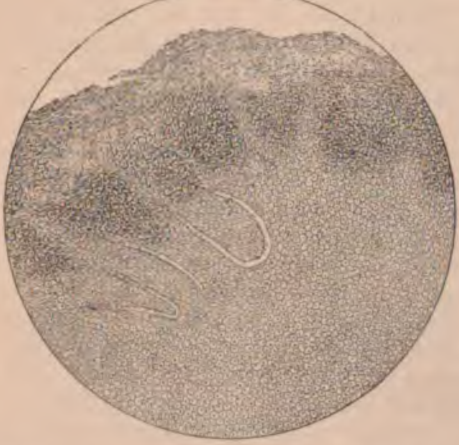


Section of a Granulation-tumor-polypus, from Micro-photograph of Specimen Prepared by Drs. R. W. Seiss and Walter Chrystie for the Author.

Soft or Mucous Papillomata (see Fig. 94) occur as large, club-shaped tumors, of light color, elastic, and not readily bleeding under the touch. They are usually found in cases where the irritation has been very prolonged, but not of a high grade of intensity. They comprise about ninety per cent. of all aural polypi other than granulation-tumors. Their surface is generally much lobulated, giving frequently a mulberry-like appearance to the growth.

A description of the specimen from which the accompanying micro-photograph was taken will perfectly illustrate the typical

Fig. 94.



SECTION OF A SOFT PAPILLOMA-POLYPUS, FROM MICRO-PHOTOGRAPH OF A SPECIMEN PREPARED BY DRS. R. W. SEISS AND WALTER CHRYSTIE FOR THE AUTHOR.

structure of these neoplasms. The stroma is composed of dense, somewhat imperfectly developed connective tissue, which sends out numerous papillary projections, each containing a capillary loop. Each projection is covered by a layer of cuboidal epithelium, which is so great in amount as to fill up the sulci between the pillars. Many of the pillars send out secondary branching papillæ. Near the surface of the growth the epithelium becomes squamous; in some examples of this neoplasm this covering is hard and bony in character. Spots of myxomatous degeneration frequently occur in these polypi, especially when they have long persisted. Very vascular, or even cavernous examples of this class are occasionally met.

Fibromata, in the true meaning of the term, are exceedingly rare; the so-called "fibrous tumor" of clinical otology being, in the majority of instances, examples of soft papillomata. They are developed from the periosteal lining of the tympanic cavity,[1] and are large, dense, pale-colored polypi, usually covered by a multiple layer of pavement epithelium. These structures exhibit a more or less fibrillated, firm connective tissue, in which are found numerous connective-tissue corpuscles. They are sometimes vascular or cavernous. The intracellular substance is said, by Schwartze, to be "sometimes perfectly homogeneous, sometimes grossly fibrillary."[1] Patches of myxomatous degeneration are especially frequent in these growths, and the epithelial investment may become hard and skin-like. They also show a marked tendency to undergo cavernous change.

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[1] Schwartze, Path. Anat. of the Ear, p. 126.

Myxomata occurring in the ear are yet rarer than polypoid fibromata, not half a dozen instances having yet been satisfactorily described. They are exceedingly soft, gelatinous tumors, springing from a broad base, and are mostly covered by multiple layers of pavement-epithelium. Their stroma consists of a homogeneous, gelatinous tissue crossed by a network of spindle- and star-shaped cells, and in which are embedded a few round, granular cells; occasionally these tumors are rich in bloodvessels, and may contain organized blood-clots.

To account for these growths, according to the now rarely received theory of Cohnheim, by the fact that the fœtal tympanum contains mucous tissue, seems altogether erroneous, especially as myxomata frequently occur in parts of the body where no mucous embryonal tissue is to be found.

The Angioma of Buck[2] is described as follows: "The entire mass" (of the tumor) "consisted of bloodvessels, radiating from an irregularly shaped central cavity, and separated by a network of fibrous connective tissue, holding blood corpuscles in its meshes." It appears to have been a true independent neoplasm, but as this is the only reliable instance on record of its occurrence, so far as we are aware, it can as yet only be regarded as a pathological curiosity.

"Cysts," "organized blood-clots," "venous blood sacs," and a few other formations growing within the ear, have been more or less vaguely described by different authors. It is impossible to give to any of them definite pathological significance.

J. Orne Green[3] speaks of "polypoid growths," "which are undoubtedly hypertrophies" of "the papillæ on the dermoid layer of the membrana tympani;" but Dr. Green gives no detailed account of their structure. They seem to be very rare in their occurrence.

Any of the four classes of aural polypi just described may present examples of cystic, cheesy, and teleangiectatic changes having taken place within the structure of the neoplasm. Extensive fatty degeneration may also be present; which may spontaneously amputate the growth by destruction of its pedicle.

Osseous and cholesteatomatous masses have also been described as occurring in the substance of aural polypi. Epithelioma, osteosarcoma, and gummata have been delineated by various writers as arising from the middle ear; all are exceedingly rare, and have been but imperfectly described.

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[1] Op. cit., p. 127.

[2] Transactions American Otological Society, 1870.

[3] Ibid. Report on Progress of Otology.

All aural tumors belonging to any of the four classes of our schedule—possibly with the exception of the fibromata—are entirely benignant, showing no propensity whatever to involve surrounding healthy tissue, nor tendency towards recidivity *after thorough removal* and proper after-treatment. Fibroids may, possibly, at times exhibit the rapid growth and semi-malignant character of some of those found in the nasal fossæ.

An Organized Vesicular Polypus, containing the Necrosed Long Process of the Incus.—After the removal of a soft polypus as large as a pea from the left ear of a boy seven years old, an inmate of the surgical ward of the Presbyterian Hospital in Philadelphia, a bright red body was discovered, which, at first sight, was supposed to be a clot of blood. It was gently pulled out, and found to be an organized vesicular body, containing, apparently, fluid blood, and a small, hard substance embedded in it. This proved to be a portion of one of the auditory ossicles, and upon its being subjected to examination by Prof. H. Allen, of the University of Pennsylvania, it was pronounced by him to be the *long process of the incus.* The vesicle-like polypus, when placed in a mixture of equal parts of water and glycerine, gave up its blood, but retained a membranous, sac-like appearance, though pale and flaccid.

Symptoms.—It cannot be said that there is any special train of symptoms which betray the presence of an aural polypus. Wherever a chronic purulent discharge from the ear has existed a long time, the presence of a polypus may be suspected, especially if from time to time there has been hemorrhage from the ear, but the usual symptoms are only those of chronic otorrhœa. In rare instances, aural polypi may be productive of hemiplegia, as shown by Schwartze.[1] In such instances it is supposed that retention of pus, inducing a severer inflammation in the tympanum, causes a hyperæmia of the meninges of the brain. In the case given by Schwartze, there was incomplete hemiplegia on the corresponding side, together with anæsthesia and ptosis, without facial paralysis. Removal of the polypi caused the symptoms to vanish.

Hemicrania, sensations of fulness, vertigo, retention of pus, nausea, and vomiting have been observed as results of the presence of a large, obstructive polypus in the auditory canal; but they are not to be regarded as characteristic of the presence of polypi generally. The vast majority of aural polypi are first discovered by the surgeon when the patient applies for relief from an aural discharge, the latter being the only symptom.

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[1] Archiv f. Ohrenh., Bd. iv. S. 147.

Spontaneous Detachment of Polypi.—Polypi sometimes become detached without any greater application of force than syringing. In some instances they undergo what is termed spontaneous detachment. Schwartze[1] observed two such cases: one, the detachment of a so-called mucous polypus; another, that of a sarcomatous growth. He also quotes Saissy, Toynbee, and Kramer as having observed similar occurrences.

In three instances I have observed the detachment of small polypi by syringing: one, from the wall of the meatus; another, from a small opening in the posterior-superior quadrant of the drum-head. In the former case, a discharge had lasted for a long time, much to the annoyance of the patient, a lady twenty years old. The discharge ceased, and the perforation closed as soon as the polypus was washed out. In the second case there was no perforation of the drum-head.

Treatment of Aural Polypus.—The treatment of an aural polyp *begins* with its removal. The after-treatment of the ear, and especially of the point to which the growth was attached, is as important as removing the polypus. The patient should be told this and enjoined to persevere, after the evulsion of the growth, with the subsequent local treatment of the ear at the hands of the surgeon. Unless this is properly and thoroughly done, it is almost useless to remove the polypus, for the patient will at least have undergone some annoyance and pain by the extraction of the growth, and, after a short freedom from it, a new one will spring up. Many patients are deterred from undergoing the removal of an aural polyp because of their fear of a renewal of the growth. This will, indeed, happen if, after the polypus is removed, the point of attachment is not treated; but if the after-treatment is properly gone through with, no fresh polypus will grow from the point of previous attachment, and, furthermore, the tendency to their formation anywhere in the ear will be removed.

The best instrument for the removal of an aural polyp is Wilde's[2] snare, or Blake's[3] modification of it. Wilde's instrument consists of a fine steel stem five inches long, and bent in the middle (Fig. 95). It is provided with a movable bar which slides on the square portion of the shaft near the handle, which latter part fits over the thumb. At the distal end there is a button-like projection perforated by holes running parallel to the stem, one on each side of it. There are also two small rings at the angle. Through these a fine wire of silver, platinum, or iron, or a strand of Jack-line or fishing-gimp (Hinton) may be drawn to form a small loop or noose at the point, while the ends of the wire, or whatever is used to form the snare, are coiled about the crossbar at the handle.

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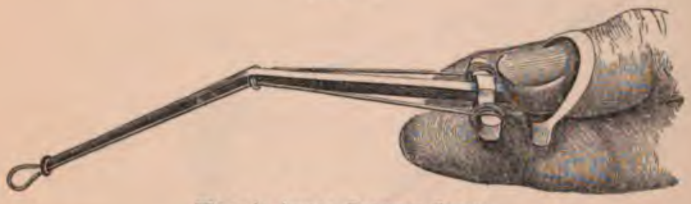
[1] Archiv f. Ohrenh., Bd. ii. S. 9. 1867.

[2] Diseases of the Ear, Phila., 1853, p. 397.

[3] Arch. of Oph. and Otol., vol. i. p. 435, 1870.

When the instrument is in order, the crossbar may be at any point on its part of the shaft, most convenient to the su rgeon By traction on the crossbar, the loop at the end is narrowed and the polypus or its pedicle constricted.

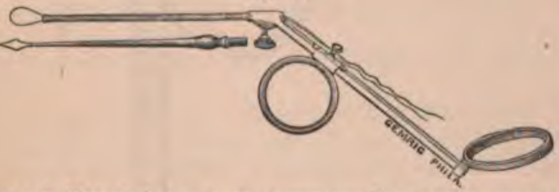
Fig. 95.



WILDE'S AURAL POLYPUS SNARE.

Blake's modification of the valuable instrument of Wilde. consists chiefly in causing the wire, left bare between the point and the angle in the shaft, to run in a miniature barrel slightly widened at the end and perforated by two holes through which a wire passes to form the loop. Instead of fastening the free ends of the wire to a crossbar, they are wound in opposite directions around a button on top of a short, square canule, 1 cm. long, which is made to slide smoothly on the square portion of the shaft. To the under surface of the canule there is attached a ring in the plane of the long axis of the instrument, by which traction is made and the loop narrowed. The handle or thumb-piece of the instrument is formed of a ring placed at an angle of 45°, transversely to the shaft.

Fig. 96.

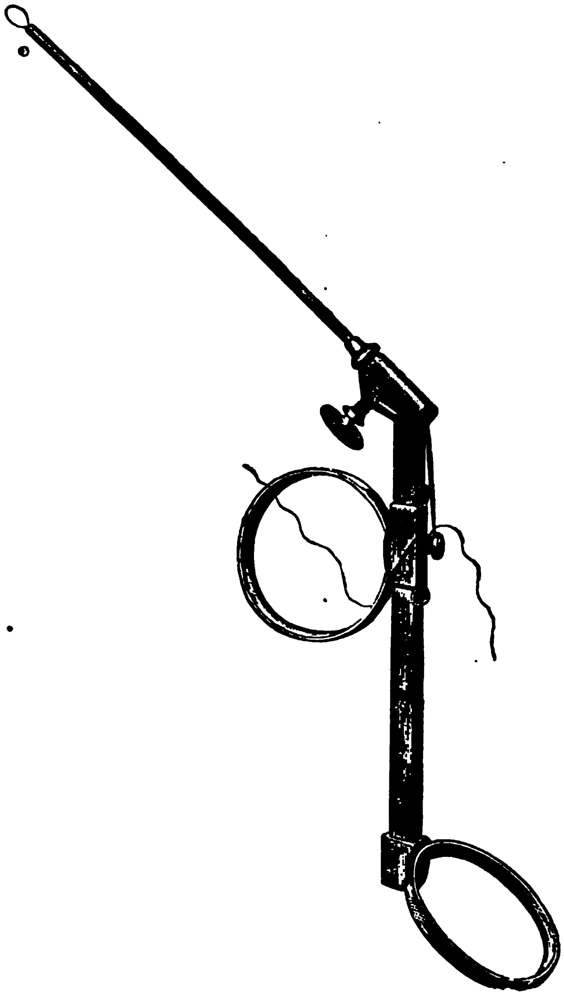


BLAKE'S WILDE'S SNARE, WITH ADJUSTABLE PARACENTESIS-NEEDLE.

The aforesaid barrel is made to fit into a socket at the angle of the instrument and held in place by a set-screw. Dr. Blake has also planned a paracentesis-needle to go with this instrument, and which is made to fit into the socket at the angle where it is held in place by means of the set-screw. The whole affords an admirable improvement on the original Wilde's snare.

The author, some years ago, made the end of the canula

Fig. 97.

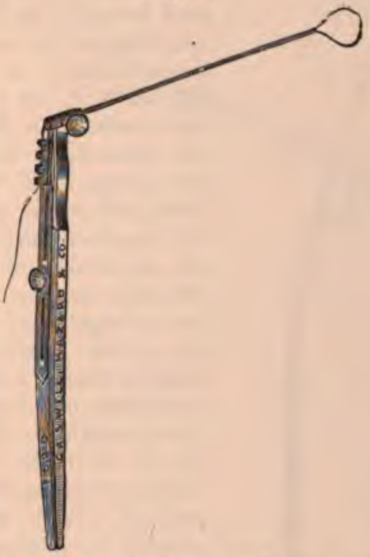


AURAL POLYPUS SNARE, WITH FENESTRATED CANULA.

fenestrated, so as to prevent drawing the loop into the barrel, and thus delaying an operation. The canula was made to consist of steel, and to be from 1 to 1.50 mm. in diameter. In this instrument the author has used brass piano-wire, or fine brass wire used by saddlers for sewing. The instrument is shown in its natural size, with a figure of the fenestra at its end, in Fig. 97.

Dr. Samuel Sexton,[1] of New York, has further improved this form of polypus snare, by giving the wire "three abrupt turns through notches cut rather deeply in the slide for its reception." (Fig. 98.)

Fig. 98.



SEXTON'S POLYPUS SNARE, WITH NOTCHED SLIDE FOR FASTENING THE ENDS OF THE WIRE.

Before the snare or any other means is employed for the removal of a polypus, the latter should be carefully examined by a curved probe, in order to determine if possible the point of attachment of the base or pedicle of the growth. I have gained great aid in this search by means of a very simple instrument, consisting of a platinum wire ring 4 mm. in diameter, soldered very neatly to a cotton-holder. This is as large a ring as will prove useful; smaller ones may be used with advantage. By passing this instrument down the well-lighted canal, the polyp may be very much more easily and thoroughly moved about on its attachment by means of this ring-end, than if the growth were touched by a smooth and blunt probe. By observing on which side the ring glides most easily, or where it meets with a resistance, a fair, if not a positive idea of the point of attachment of the polypus may be obtained. This instrument is also an excellent means of scraping off the slough from a cauterized pedicle. An ordinary silver probe may also be used for manipulation of the polyp.

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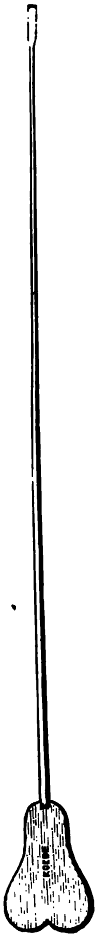
[1] American Journal of Otology, vol. ii. p. 298, 1880.

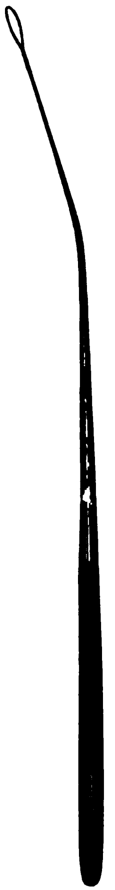
The Use of the Snare.—With the canal well lighted by means of the forehead-mirror, let the snare be passed over the polyp and brought as near the point of attachment as possible. There is no sensibility in the growth, but the walls of the canal which must be touched in this manipulation are extremely sensitive, and unless great skill be used, the patient will suffer pain. As a rule, the snare should be used without an ear-funnel or speculum in the external meatus. When the snare has disappeared over the polyp, let gentle constriction and traction be made, and then, if the instrument has been well adjusted, the growth, or the major portion of it, will be removed. Some hemorrhage will usually ensue, and all further operative endeavor should be postponed until a clear view of the external canal and the fundus can be obtained. Itard[1] observed a rapid hemorrhage of four ounces of blood after the removal of a polyp from each ear, and Moos[2] records an "alarming hemorrhage from the ear after the extraction of a small polypus from the short process of the malleus, necessitating a tampon." But these are rare occurrences, and are not to be cited to deter from the removal of an aural polyp as soon as it is discovered.

Fig. 99.



Silver Probe for Manipulation of Polypi.

Fig. 100.



Permanent Platinum Wire Loop on Fexible Shaft.

Polypus Hook. — When polypi are quite small, not more than half the diameter of the auditory canal, I have found it very convenient to use a small steel hook, which I have caused to be fitted to an adjustable holder.

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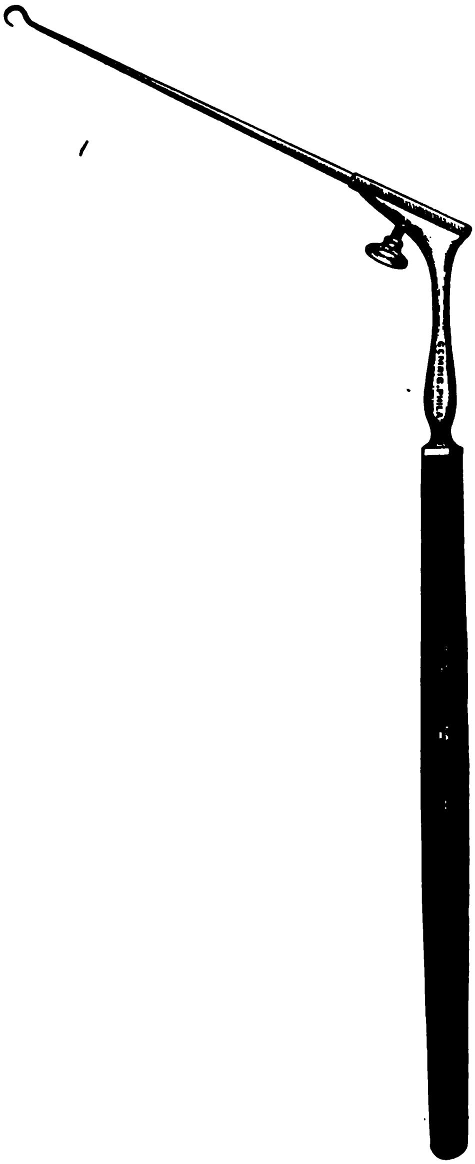
[1] Maladies de l'Oreille. tome ii. p. 124, 1821.

[2] Arch. of Oph. and Otol., vol. iii. p. 107, 1873.

By this means, which is quite simple and attended with less darkening of the canal than the use of the more cumbrous wire-snare, a small polypus can be lifted from its stem without

Fig. 101.



Polypus Hook.

touching the wall of the canal, and, consequently, without any pain to the patient.

Dr. Jacoby,[1] of Breslau, has applied the galvano-caustic method to the removal and treatment of granulations and polypi in the ear, with asserted success. But it is a means no surer nor more rapid than the more usual and less complicated methods just detailed, and certainly no less, but perhaps more, painful.

Mr. Toynbee proposed to destroy polypi by applying to them potassa cum calce, an unmanageable, slow, and dangerous procedure, and one not at all in practice now-a-days. In the latter part of his career, Mr. Toynbee succeeded in destroying polypi by gentle and continued pressure by means of small pieces of sponge or wool.[2]

The late Dr. Edward H. Clarke[3] succeeded in causing aural polypi to disappear by injecting into their structure, by means of a hypodermic syringe, a few drops of the solution of perchloride of iron, or of persulphate of iron.

Treatment after the removal of the Aural Polyp.—A number of suggestions have been made respecting the applications to be made to the diseased ear after the polyp is removed by evulsion. Both the matter and the mode of its application are deserving of the greatest consideration. The best applications are nitrate of silver and chromic acid, both of which are to be used in concentrated solution.

Nitrate of silver in the solid state may be applied by means of a porte-caustique, as recommended by Wilde. But he enjoined the greatest care in getting to the seat of the polypus, and only there, lest the auditory canal be cauterized and inflamed. But at best the "solid stick" is a dangerous application about the ear, and should, therefore, be kept out. A saturated aqueous solution of nitrate of silver (480 gr. to f℥j) may be advantageously applied to the seat of the polypus and any surrounding granular surface, by means of a tuft of cotton on the cotton-holder. This will cause no pain so long as it is not brought in contact with the skin of the auditory canal. The remnant of the polyp and the more or less granular mucous tissues in the drum-cavity are not sensitive to it. But even the saturated solution of nitrate of silver may act too slowly, on account of the superficial slough which it forms.

Chromic acid, an escharotic more powerful than the preceding one, may be used with great and rapid aid in removing granulations, or the remnants of a polypus, as has been shown by

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[1] Archiv f. Ohrenh., Bd. v. S. 1, and Bd. vi. S. 235.

[2] See "Diseases of the Ear," supplement by Mr. Hinton, p. 433.

[3] Observations on the Nature and Treatment of Polypus of the Ear, Boston, 1867, p 71.

Dr. W. W. Seely,[1] of Cincinnati. I have employed this for the destruction of the broad attachment of the large mucous, and fibroid polypi, but not very often for the destruction of smaller polypoid growths or their attachments. Its application may cause pain, which comes on an hour or more after the root of the polypus is touched, and continues as a dull aching for some time. This gradually wears off, if the acid has not been applied too freely, and every possible precaution must be observed to avoid this, and when the patient is next seen it will be found that a large eschar has formed at the points touched by the acid. Under no other application does the remnant of the pedicle of a polypus disappear so surely and so rapidly. It should be applied in the same manner as the solution of silver. A few crystals should be crushed and slightly moistened with water, and into this concentrated mixture the tuft, prepared as described above, when alluding to the use of nitrate of silver, should be dipped and then conveyed to the diseased spot. The latter may be gently brushed or pressed upon by the tuft of cotton thus prepared. The cotton tuft must not contain much acid, nor should that which it carries be too fluid—it should be pasty—for otherwise when the cotton is pressed on the granulation, or the cut surface of a pedicle, an excess of acid would be squeezed out, and run upon the healthy tissues. But care will prevent any such mishap, and enable any one to command the rapid and thoroughly curative action of chromic acid.

The consideration of the results named under the fourth head (p. 478) will be reserved for the following chapter.

CHAPTER VIII.

COURSE AND CONSEQUENCES OF CHRONIC PURULENT INFLAMMATION (*Continued*).

CHRONIC suppuration of the tympanum, after a longer or a shorter duration, may extend inward toward the labyrinth and the auditory nerve, upward through the tegmen tympani, directly toward the middle lobe of the brain, backward through the mastoid antrum to the mastoid portion, its cells, and the lateral sinus, or outward to the bony auditory canal.

The close anatomical relation between the tympanic cavity and the above-named regions, has already been pointed out when considering the anatomy of the middle ear. But it will be necessary to recall that relation at this time in order to obtain a juster idea of the mode and extent of the ravages made by chronic suppuration in the various parts of the temporal bone, and even in the bones adjoining it.

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[1] Transactions American Otol. Soc , vol. i. p. 166, 1871.

Chronic suppuration of the middle ear advances by the successive stages of ulceration of the mucous membrane, periostitis, ostitis, caries, and necrosis of subjacent bones. The interval between the acute stage and these successive chronic stages, varies greatly in length. In some instances the acute stage is rapidly succeeded by all the others, even the necrotic exfoliation of some of the most important parts of the internal ear, while in others, a generation, or an ordinary lifetime, may elapse before the chronic process in the mucous membrane seems to leap at a bound to caries and necrosis of the bone beneath. And this is true, whether the advance of the tympanic disease is inward, backward, upward, or outward.

The least common result of such a process is necrosis and exfoliation of the cochlea, either alone or in conjunction with the rest, or parts of the labyrinth, and other portions of the temporal bone.

After a chronic suppuration has been in process for a period varying from a year or two to thirty or forty years, during which time the patient has suffered from nothing but the discharge, quite suddenly a new train of symptoms may be presented. These consist chiefly in an attack of severe pain in the ear, without any apparent cause so far as the patient can assign, swelling about the auricle, and bulging of the latter from the side of the head, chill, fever, constipation, intense vertigo, nausea, vomiting, and sometimes a peculiarly distressing and intense tinnitus in the affected ear. The hardness of hearing is increased to total deafness. To these symptoms may be added those consisting of paralysis of the facial muscles, and of the extremities on the side corresponding to the diseased ear, delirium, coma, and death. Though not infrequently, after the paralysis of the face and the extremities has been fully established, it, with the pain, tinnitus, nausea, vertigo, and vomiting, is quite suddenly relieved by a copious discharge of pus from the ear. The patient then recovers; with, however, the absolute deafness characteristic of destruction of the labyrinth, and with some continued discharge from the ear. Upon examining the external ear in such cases, not only bare bone may be felt, but loose sequestra are found at, or near the external auditory canal, or protruding from the opening of a sinus behind the auricle. In those cases in which the cochlea has been thrown off as a separate sequestrum, it has been found in the auditory canal, from which it has been lifted with ease. When joined to other bony tissues, forming a large sequestrum, the whole has been worked from the meatus, or from the aforesaid opening behind the auricle.

Exfoliation of the Cochlea.—Exfoliation of the cochlea, as a sequestrum separate from the rest of the labyrinth, has been observed and described by Ménière,[1] Gruber,[2] Hinton,[3] Toynbee,[4] Cassells,[5] Parreidt,[6] Boeck,[7] Dennert,[8] and Lucæ.[9]

In the vast majority of these cases the cochlea was taken out, or came out during life, the patient, of course, remaining totally deaf in the affected ear, but free from facial paralysis. Only in two cases, that of Boeck, and in one of the three of Ménière, was the necrosed cochlea found after death as a free sequestrum in the external ear. The case of Boeck was further exceptionally characterized by facial paralysis. The patient, a child under two years of age, succumbed during the progress of the necrotic disease of the internal ear, from acute hydrocephalus. In all of these cases the cochlea was removed through the external auditory meatus; not uncommonly, before the acute symptoms of the detachment of the sequestrum, the external ear and mastoid portion are free from pain or tenderness on pressure, a very marked, though not an invariable diagnostic difference between deep-seated inflammation of the labyrinth and mastoid disease. Sometimes detachment of pieces of the bony auditory canal precede the exfoliation of the cochlea.

Facial paralysis is rarely observed, and never permanent, when the cochlea alone is thrown off. From recorded accounts it appears that only Toynbee has observed this symptom in connection with exfoliation, during life, of the separate cochlea. Necrosis and exfoliation of both cochleæ have been observed only by Gruber.[10] The patient, a lad twelve years old, who had suffered from otorrhœa for several years after scarlatina, showed no signs of facial paralysis, but remained totally deaf.

Exfoliation of the Cochlea, Vestibule, Semicircular Canals, and Deeper Parts.—Larger sequestra, composed of not only the cochlea, but the rest of the labyrinth, the porus acusticus internus, and even the major portion of the temporal bone, have been removed during life and described, by Wilde,[1] Shaw,[2] Toynbee,[3] C. R. Agnew,[4] Voltolini,[5] O. D. Pomeroy,[6] C. J. Blake,[7] and Samuel Sexton.[8]

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[1] Gazette Méd. de Paris, No. 50, 1857.

[2] Wiener Allg. Med. Zeitung, 1864; also "Lehrbuch," p. 542, 1870.

[3] See Toynbee, Archiv f. Ohrenh., Bd. i. S. 114, 1864.

[4] Ibid.

[5] "Questions of Aural Surgery," by James Hinton, London, 1874, p. 296.

[6] See Schwartze, Archiv f. Ohrenh., Bd. ix. S. 238, 1875.

[7] Ibid.

[8] Archiv f. Ohrenh., Bd. x. S. 231, 1876.

[9] Ibid., Bd. x. S. 236, 1876.

[10] Wiener Allg. Med. Zeitung, 1864.

In the two cases of Toynbee the sequestra were not removed until after death, which occurred in consequence of the severe and previously neglected aural disease. In the other cases the large sequestra were removed through the external meatus, excepting in the case under the care of Dr. Pomeroy, in which the sequestrum, the major part of the temporal bone, came out by a natural process from the opening of a sinus behind the auricle. The implication in the necrosis of so much of the temporal bone as ensues when the entire labyrinth, the porus acusticus internus, and other parts of the petrous bone are thus thrown off as sequestra, is naturally attended with facial paralysis as a *markedly characteristic* symptom, besides the intense deafness.

Besides the invariably ensuing facial paralysis, which may be permanent, there may occur, as in the case reported by Wilde, temporary paralysis of the arm and leg on the side of the diseased ear. The latter paralysis, however, vanishes upon the cessation of the acute symptoms, and may be considered as due to pressure from the retained pus in the ear. All the symptoms observed in connection with necrosis and exfoliation of the cochlea, are intensified when the necrosis involves other parts of the labyrinth and the neighboring petrous bone.

Not only are the deep-seated pains, tinnitus aurium, deafness, vertigo, nausea, and vomiting urgent symptoms, but the external ear is tumefied and more sensitive to pressure; the mastoid portion is more apt to become tender and painful; an abscess may form there, and opening, leave a sinus which leads to dead bone; the discharge is excessively fetid; the cerebral symptoms often threatening; the gait may be altered for long periods, as in a case reported by Sexton; convulsions and coma may supervene, and death occur, as shown in two cases recorded by Toynbee. In one of these an opening was found leading from the sequestrum in the posterior part of the petrous bone to the jugular fossa. In necrosis originating in the inner wall of the tympanum, there seems to be a tendency on the part of the disease to enucleate the hard and resistant labyrinth from the surrounding, more porous part of the petrous bone in which it lies embedded.

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[1] Treatise on Diseases of the Ear, Phila., 1853, p. 358. Sir Philip Crampton's case.

[2] Seventh Vol. Trans. Path. Soc. London. See Toynbee, Archiv f. Ohrenh., Bd. i., 1864.

[3] Two cases: Archiv f. Ohrenh., Bd. i., 1864.

[4] Amer. Med. Times, vol. vi. p. 183; also v. Troeltsch on the Ear, 2d Am. ed., p. 471, 1869.

[5] Monatschr. f. Ohrenh., 1870, No. 6.

[6] Trans. Amer. Otol. Soc., 1872.

[7] Ibid., 1880, vol. ii. p. 417.

[8] Illustrated Quarterly of Medicine and Surgery, N. Y., Jan. 1882.

Treatment.—It is usually found that up to the time the patient applies for relief from the acute and painful symptoms which have been suddenly added to the chronic aural disease, there has been almost total neglect of the ear, and that the external auditory canal is blocked by one or more polypi, which has caused a retention and consequent burrowing of pus. It, therefore, becomes necessary, as the first step in the treatment, to free the external auditory canal and permit the escape of the products of inflammation; after which, if dead bone be recognized, the escape of the sequestra should be favored, either by hygienic or direct surgical means. It not uncommonly happens that, before the sequestra of the deeper parts are removed, pieces of the more superficial parts of the external auditory canal escape or have to be pulled either from the meatus or a sinus near the auricle. If such an opening behind the ear leads to dead bone, a poultice kept constantly over the mouth of the sinus—*not over the auditory meatus*—will be found to favor greatly the process of nature in throwing off the sequestra. Traction upon the latter should *never* be made until they are entirely loose. Then, the sooner they are removed the better.

Polypi and polypoid granulations are not indicative of dead bone, yet the presence of carious bone in the ear is always attended by the growth of granulations. They are in such cases hard, sensitive to the touch, and bleed easily. These are very apt to be seated near the inner opening of a sinus, and are not uncommonly found attached to the auditory canal, thus forming an exception to the general rule in respect to the point of attachment of such growths. They are, in fact, to be regarded as exuberant granulations rather than polypi. They should be extracted if they interfere with drainage of the ear, but they will almost surely recur until the dead bone is removed. Then they will be found to disappear in the general improvement which takes place in the ear. So long as they do not interfere with the thorough cleansing of the ear, while the dead bone is still present, their presence need not be combated, beyond keeping them down to a point which permits the escape of pus and the entrance of cleansing fluids and medications.

The general constitutional treatment should be of the most supporting kind: meat, vegetables, farinaceous foods, milk, and eggs; iron, quinia, and cod-liver oil. In the more virulent cases, resembling in many respects a typhoid condition, alcoholic stimulants may be given if the failure in strength of the patient indicates such administration.

A result of neglected purulent inflammation of the tympanum, more common than caries of the cochlea and labyrinth, is inflammation, caries, and necrosis of the mastoid cells and of the entire mastoid portion of the temporal bone. No only is this a common event, but it is also a very fatal one. But this fact is not a new one to otologists; more or less distinct records of this disease can be found throughout the history of medicine and surgery. A greater want is felt in the paucity of accounts of how to prevent it; or, if it is fully established, how to recognize and cure it. Prevention becomes of greatest importance; no part of the body tolerates neglect or improper treatment so poorly as the middle ear, when attacked by chronic suppuration. Caries of the mastoid is rarely a necessary result of the latter disease; it is almost invariably traceable to neglect of the purulent tympanic disorder.

It must be remembered that the mastoid portion of the temporal bone is covered by periosteum, a continuation of that of the external auditory canal, and that its cavity consists of intercommunicating air-cells lined with mucous membrane connected with the middle ear. These cells, moreover, may extend over the upper wall of the external auditory canal, upward toward the parietal bone and inward toward the petrous part of the temporal bone; in some instances, however, even in the adult the mastoid portion is small, and its cells rudimentary.

In the normal bone, veins pass from the upper part of the mastoid cavity to the lateral, or to the superior petrosal sinus. This highly important cavity has but one outlet, viz., by means of the mastoid antrum into the tympanum. But this outlet is both small, and, so far as drainage is concerned, badly placed, since it is at the top of the cavity. Only the siphon action could empty the lower cells at the tip of the process, and it is probable that sometimes the cells are thus naturally drained when the discharge is excessive.

It seems probable that the mastoid portion and its cells resist for a long time, in some cases, the chronic ulceration in the tympanum, for in very chronic cases the remnants of the cells, or the shell of the mastoid cavity, are found choked with a cheesy mass, consisting of epithelial débris, pus, etc., forming a so-called cholesteatomatous mass. This at last, choking up every avenue of escape for the products of inflammation, becomes a distending, irritating, and poisonous mass, which, if not removed, will either induce purulent absorption, so-called pyæmia, or an irruption into the lateral sinus, or both of these events.

Mastoid Disease; Symptoms and Course.—For clinical convenience mastoid inflammation consecutive to purulent disease in the tympanum, may be divided into:

1. Periostitis of its outer surface.

2. Congestion and inflammation of the mucous membrane lining the air-cells of the mastoid cavity.

3. Caries and necrosis; followed by meningitis, thrombus in the lateral and other sinuses of the brain, embolism, pyæmia, and cerebral abscess.

1. The *first* is not uncommonly observed as an attendant of acute inflammation of the middle ear, with consecutive inflammation in the external auditory canal. It may also appear during chronic suppuration in the tympanum. An abscess may form over the mastoid as a result of this periostitis, and, in some broken-down and scrofulous diatheses, caries of the outer table may be thus induced. The latter, *asthenic* form is characterized by its painlessness; the former, the *sthenic* type, by the reverse. The asthenic process may occur as a sequel of diphtheria in children, as shown by the following cases:

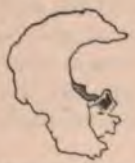
Case I. Frank H., 16 months old, born in Philadelphia, was attacked by diphtheria in March, 1875. I saw the case six weeks after the onset of the diphtheria. The mother of the child stated that, on the fourth day after the initial symptoms of diphtheria, she noticed a red swelling behind the right auricle over the mastoid. This swelling increased rapidly in size, but is said to have caused the child *no* pain, nor was it markedly tender on pressure. There was no history of any previous aural disease, nor of any diphtheritic deposit in or about the external ear.

The mastoid abscess was poulticed, and in a few days it was opened by the family physician, with a free discharge of pus. From that time until I saw the patient a constant and offensive discharge continued from the mastoid incision and from the ear.

I examined the case for the first time on the 22d of April, 1875, about six weeks after the onset of the diphtheritic disease, and found by the probe dead but adherent bone on the mastoid portion near the external auditory canal. The auditory passage was blocked by granulations. There was also considerable swelling about the ear, and the pus tended to burrow in the direction of the sterno-cleido-mastoid muscle. There was a sinus running from the mastoid abscess into the external auditory canal, which will, I think, account for the discharge from the ear and the granulations alluded to above, as well as lend probability to the statement of the mother that the mastoid disease preceded any kind of discharge from the external auditory canal. On the 27th of April, 1875, I made an incision, an inch long, over the mastoid portion, which gave free exit to the pus, and diminished the discharge from the ear, as well as the tendency on the part of the pus to burrow downward into the neck. Through this incision the denuded bone could be felt.

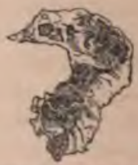
In a month, on the 28th of May, there was a detached piece of bone at the opening I had made over the mastoid, and, on June 1, I extracted the sequestrum represented in Figs. 102 and 103. The general swelling around the ear had gone down. The local treatment up to this time had been simple cleansing of the ear and keeping the mastoid incision free enough for drainage, and to permit the escape of dead bone.

Fig. 102.



OUTER SURFACE. (Natural size.)

Fig. 103.



INNER SURFACE. (Natural size.)

The child was considerably run down by his blood-disease, but, with tonics and the good effects of a summer in the country, rapidly grew better. The ear was kept carefully cleansed, as was the opening of the sinus behind the auricle, and a weak solution of sulphate of copper (gr. iij to f℥j) was used for instillation and injection.

In two hundred and ninety-five days after the free incision over the mastoid, the sinus behind the auricle finally closed; a slight discharge—a few drops—still came from the external ear every day or two.

So far as could be ascertained in so young a patient, then about twenty-six months old, there was no impairment of hearing as the result of the mastoid disease.

In this child some of the chain of glands situated over the mastoid portion of the temporal bone and along the tract of the sterno-cleido-mastoid muscle, successively enlarged and sluggishly suppurated, without pain, which would seem to indicate that the inflammation over the mastoid portion, and of its outer table, in this case, was due to an inflammation of such a gland, the first in the chain to be diseased by the diphtheritic poison. Such a disease as this, occurring *over the outer wall* of the mastoid portion *in a child*, becomes of moment not only to the hearing, but even to the life of the patient. The latter is due to the fact that *in children* there is much greater probability of an extension inward of such a disease as I have just described, than there is of its successful outward termination, for the dense tissues over the mastoid in young children are much more resistant than the thin and somewhat cribriform or dehiscent outer table of the mastoid portion of the temporal bone. Hence, in just such a sluggish form of abscess over the mastoid as was found in this child, there may be danger of a burrowing inward of the disease, deep inflammation of the mastoid cells, caries extending into the cranial cavity, pyæmia, and death.

That this disease originated outside of the mastoid portion of the temporal bone, is further shown by the first aural symptom, if it may be called such, viz., the mastoid swelling, unaccompanied by pain in the ear. Had the disease started in the middle ear or in the mastoid cells, there would surely have been symptoms of great suffering in the child at the outset, and subsequently, it is highly probable, we should have found an impairment of hearing; whereas that function did not appear to be affected at any time during the disease.

The following case is one resulting from scarlatina and diphtheria combined; but in it, too, I am inclined to regard the carious erosion as starting on the outer side of the mastoid:

Case II. Mary Coogan was attacked in April, 1876, when three and a half years old, with diphtheria and scarlatina. The throat symptoms were very bad.

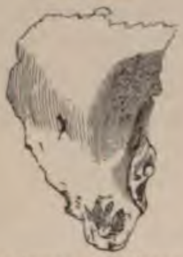
In about three weeks after the beginning of the fever, which was soon followed by a running from the right ear without pain, facial paralysis was observed on the right side, and in three weeks an abscess formed over the mastoid and spontaneously opened. There was no pain at any time. The facial paralysis now began to disappear, and was only very slightly visible in October, 1876, when I first saw her; in a few weeks it vanished entirely. The external auditory canal was blocked with granulations springing from the posterior wall; there was a large sinus close to and behind the auricle leading to the external auditory canal; offensive pus was discharged from the meatus and the sinus; denuded bone was felt with the probe passed into the sinus and external auditory meatus. The child was given cod-liver oil and some other tonics; a poultice was kept constantly over the opening of the sinus *behind* the auricle; and by December, 1876, a sequestrum could be distinguished, one end of which began to protrude by January, 1877, from the sinus. The sequestrum appeared to consist of the major part of the outer wall of the mastoid and that part of the latter which goes to form the posterior wall of the bony auditory canal. And this was verified by the extraction of the sequestrum through the sinus on February 12, 1877.

As shown in the accompanying woodcuts (Figs. 104 and 105), the sequestrum consisted of a large number of the air-cells of the mastoid cavity as well as of a large part of its anterior and outer wall.

The ear was syringed with warm water for a few days; the discharge from the ear ceased entirely; the granulations shrivelled and disappeared; the opening behind the auricle closed.

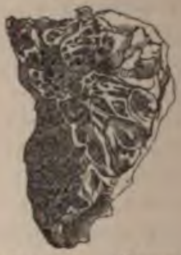
The *sthenic* variety of mastoid periostitis is characterized by pain and tenderness in the mastoid portion, with some redness of the skin. It may mislead the observer into the idea that it is inflammation of the mastoid cells. But the less deep-seated pain in the ear and head, and the readiness with which the periostitis yields to leeching or a deep incision (Wilde), will serve as diagnostic points.

Fig. 104.



OUTER SURFACE. (Natural size.)

Fig. 105.



INNER SURFACE. (Natural size.)

It must be borne in mind, however, that inflammation of the external periosteum may be associated with deeper inflammation in the mastoid cavity.

2. *Congestion and Inflammation of the Mucous Membrane of the Mastoid Cells.*—A simple congestion of the mastoid cells may coexist with a tympanic inflammation. The pain may not be referred to the mastoid in all cases, though usually the pain is thus referred, and there is noted some swelling over the mastoid. This congestive process may readily yield to treatment or even undergo resolution. If not, there may ensue a deposition of a reddish, pulpy material, as shown by A. H. Buck,[1] followed by suppuration, caries, and necrosis in and about the mastoid cavity.

In some instances, after the congestive stage has been fully established, instead of an active inflammation, there ensues a subacute process in the mastoid cells, analogous to the chronic catarrh supervening upon a severe congestion of the middle ear. It was noted, when alluding to inflammatory processes in the middle ear, that although a congestion, in some instances, was followed by destructive suppuration, in others it was succeeded by the more conservative sclerotic process known as chronic catarrhal thickening or proliferation.

An analogous process may succeed the congestive stage in an inflammatory process in the mastoid cavity, and lead to thickening of the mucous membrane covering the bony septa between the mastoid cells, and to an hyperostosis of the latter. That such a slow and insidious process may occur in the middle ear and mastoid cavity seems probable from the cheesy accumulations almost invariably found in the worst cases of necrosis of the mastoid cells and temporal bone.

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[1] Archives of Oph. and Otol., vol. iii., 1873.

3. *Carious Inflammation of the Mastoid Cells.*—Leaving out of consideration those extraordinary cases of acute inflammation of the mastoid cells, in a previously entirely healthy ear, it may be stated that after a purulent inflammation has existed for a longer or shorter time in the middle ear, an acute and virulent inflammatory process seems to be superadded to the chronic process already fastened on the organ of hearing. This acute stage in the disease already existing in the mucous membrane of the middle ear and mastoid cells, is analogous to a similar process in a diseased mucous membrane anywhere else in the body. Hence an early symptom of the acute engorgement of the vessels in the mucous lining of the ear, is a diminution or an entire cessation of the discharge which may have been existing for a long time. And just because fatal cases have been, for the above reasons, preceded by a cessation of discharge, there may have arisen the prejudice against stopping an aural discharge. But the same argument might be used against stopping a chronic discharge from the bowels or the lungs.

After an unusual exposure to cold, after a blow on the diseased ear, or in the natural course of the purulent tympanic disease, severe and increasing pain is felt in the organ, which bids defiance to all ordinary remedies for relief; or, if a temporary relief be experienced by fomentations, leeching, and opium, the pain returns very quickly, and perhaps with greater intensity.

The discharge, which, as stated, had at first ceased, may be renewed, though altered in appearance and usually offensive in odor. The mastoid region becomes very sensitive to pressure, the skin over it becomes slightly boggy and reddened, the deep-seated pain in the ear is found to be shooting forwards toward the brow, and upwards to the vertex, and backwards toward the occiput, and the auricle may, during the more acute paroxysms of pain, stand out farther from the head than its fellow; but this symptom may disappear in a few hours, to be observed when another paroxysm of pain comes on. This variability in the position of the auricle, is a marked diagnostic symptom of mastoid affections, and should obtain earnest attention from the surgeon. In some instances it is very striking, and, as after abstraction of blood it subsides, it may be due to the intense engorgement of the dense tissues about the ear. It surely is not due to the formation of pus, for it appears too soon in the disease. It may be analogous to the swellings lower down in the neck, in the sterno-cleido-mastoid muscle, which have been observed by some (Voltolini and others) as an accompaniment of mastoid periostitis. These swellings, though large, red, tender, and painful, usually disappear without suppuration. The tendency of mastoid pain to exacerbations, chiefly at night, is worthy of note. As the mastoid symptoms increase in severity, the general appearance and condition of the patient are most striking and pitiable. Not uncommonly the sufferer continues to go about his daily duties, especially when unaware of the true nature of his disease. The pain deep in the ear and head is most intense, the pulse—often slow and weak at first—becomes very rapid, sleep is out of the question, the appetite fails, nausea and vomiting ensue, the tongue becomes dry and rough, and the face becomes peculiarly haggard and bathed in cold sweat. Though very weak, the patient may still continue to walk about, not unfrequently coming regularly to his physician. But, gradually, unless relief is obtained by evacuation of the products of inflammation which have accumulated in the mastoid, it is observed that the answers of the patient are becoming incorrect respecting even his name and place of residence, that his intellect is confused, and that his strength is failing. Rigors and irregular fever set in, every movement of the body now causes almost indescribable agony in the head; stupor and coma, with alteration in the size of the pupil on the affected side of the head, are noted in rapid succession, and, unless speedy relief is given, death supervenes.

This train of symptoms is not obscure, but points most positively to the true nature of the terrible disease of which it might be said to be eminently characteristic. And yet a true diagnosis is rarely made until too late, the disease being vaguely called cerebral. But in most cases its cerebral character is in no way a necessary one, and would either never show itself, or be obliterated entirely, if prompt and proper treatment were applied to the disease while confined to the mastoid. As it is easier for pus to find its way through the inner wall of the mastoid cavity and transverse sinus than it is to force its way through the outer mastoid table in adults, it is not likely to choose the latter way; and hence the direful accidents following pent-up pus in the mastoid cells. And yet patients have been allowed to die with no better effort for their rescue than a poultice bound over the bony cavity in which lay the cause of their dissolution.

The best that nature can do in inflammation within the mastoid cavity, is to break down by necrosis the outer mastoid table, or to force the pus through a natural dehiscence which might happen to exist in a given case. And in some instances, it would seem that nature thus gave a vent to the products of inflammation in the mastoid cells. But, in the vast majority of cases, such relief cannot be reasonably hoped for, and the natural result then is an erosion of the thin wall of the lateral sinus, or a passage of the inflammatory process to the meninges and the sinuses of the brain, by the vascular communication existing between the mastoid cavity and the former structures. Thrombi may entirely fill the lateral sinus on the side of the affected ear and extend into the corresponding petrosal sinus. These may undergo suppuration and gangrene, and give rise to embolism and blood-poisoning. A deep-seated abscess not unfrequently forms in the muscles of the neck near the affected mastoid cavity.

Cerebral abscess is not an uncommon result of mastoid disease, as well as of chronic purulent disease in the tympanum. Its origin from purulent absorption would seem to be rendered all the more positive from the fact observed by von Troeltsch, that it may occur in the brain on the side opposite to the diseased ear. The tympanic cavity, though the starting-point of these ravages, may be found in a measure intact, as though the force of the chronic suppuration had been spent on the mastoid and its vicinity. Hence, even in fatal cases of mastoid disease, the ossicles are sometimes found *in situ*, and the membrana tympani perforated but not destroyed. In very rare instances, mastoid disease may run its full course without an accompanying perforation in the drum-head.

Treatment of Mastoid Disease.—Inflammation of the periosteum will usually yield to the local abstraction of blood, which is best accomplished by thorough leeching, or by a deep incision down to the bone. The latter procedure, Wilde's incision, will not only relieve by depletion of the congested vessels, but will also have the happiest results in relieving the tension of the dense tissues over the mastoid. Without doubt, such an incision, besides giving immediate relief to the patient's pain, in many instances cuts short a process which might extend to deeper parts and produce caries of the mastoid portion. This incision should be made about one-fourth of an inch behind the attachment of the auricle, and extend for about an inch, or even an inch and a half, across the mastoid in the line of the course of the sterno-cleido-mastoid muscle. Sometimes a branch of the posterior auricular artery is severed in this operation, but the hemorrhage is of service rather than otherwise. It is to be controlled on general surgical principles. A poultice may be applied to the incision, and the latter kept open, if necessary, by means of a tent. The bone beneath the thus incised periosteum may be found entirely healthy, though inflammation may be going on in the mastoid cavity. If the mastoid cells are deeply congested or inflamed, the incision of the periosteum will be but palliative, and the renewal or increase of the pain will indicate the probability of the existence of the *second* condition of mastoid disease, viz.: *Congestion and inflammation of the mucous membrane of the mastoid cells.* If, after the above-named treatment, local depletion and the incision of the periosteum over the mastoid, the pain, which may have been further combated by anodynes, should still persist, grow worse, and be accompanied by symptoms of general constitutional derangement, the outer mastoid wall should be perforated.

Artificial Perforation of the Mastoid Portion of the Temporal Bone.—So far as the statements of the past concern this operation, they do not demand an extended reference here. Any reliable book on diseases of the ear will give details respecting the unchecked ravages of chronic otorrhœa truly appalling. It is claimed now, and with reason, that mastoid disease and its fatal results can be prevented in many, if not in most cases; or if inflammation is set up in the mastoid cells, a *safe* means of relief is afforded in the operation of perforating the outer table of the mastoid portion.

Excepting to allude briefly to a few of the prominent historical facts connected with this operation, it will not be necessary to recall the past; I shall base my statements mainly on the writings published within the last ten or twelve years by men, most of whom are yet living and working.

The history of perforation of the mastoid portion begins with the writings and operations of Jean Louis Petit,[1] and of Jasser,[2] a Prussian military surgeon. Petit died in 1750, and, as the accounts of his operations were posthumous, Jasser, who operated on the mastoid not until 1776, may have been entirely ignorant of the labors of the distinguished surgeon of France. Although both of these men operated most successfully in their first cases, the indications for the operation were evidently not clearly comprehended by their contemporaries and immediate successors. The operation was most mistakenly resorted to for the relief of deafness, and even Jasser seems to have lost sight of the real worth of the operation, viz., the *evacuation of the products of inflammation from the cavity of the mastoid portion.* As the real worth and applicability of the operation were entirely misconceived; as it was resorted to empirically, on all sides, to relieve deafness, and not to keep pus from burrowing to the brain, reports of failure and of death, consequent upon it, soon followed, and the operation was rejected without one word of justice.

No fact of history points more conclusively to the total misconception of the true intent of the operation than the fatal result of it in the case[1] of Baron von Berger, physician to the King of Denmark. Dr. Berger, having suffered for a long time with increasing deafness and noises in the ear, but without chronic suppuration, allowed himself to be thus operated on, for relief of these symptoms. The perforation of the bone was followed by injections into the cavity of the cells; fever and delirium soon set in; and, on the eleventh day, death occurred. The post-mortem revealed purulent meningitis, an almost rudimentary mastoid, and evidences that the trephine must have perforated the brain. In this instance, death must not be referred to the operation, but rather to a misconception of its application and a consequent blunder. From this time to the time of Rau,[2] the operation is alluded to rather as a curiosity of history than as one of the most valuable and simple operations in surgery. When it is remembered that this operation was a common, though a misapplied, one, it is marvellous that there are so few accounts of death from its practice, for it was a fashionable operation, until the death of Berger, for the relief of deafness *without chronic suppuration* of the ear. The revival of this operation and its true application must, according to Schwartze,[3] be conceded to Forget, in 1849, and to Follin and von Troeltsch, in 1859.

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[1] See Schwartze and Eysell, Archiv f. Ohrenh., Bd. i., N. F., 1873; also, Saissy, op. cit., p. 164.

[2] See writings of Roosa, Buck, and others.

In June, 1873, Prof. Schwartze,[4] of Halle, began a series of papers on the artificial opening of the mastoid process, with an account of cases operated upon by him. By January, 1878, a series of fifty operations on the mastoid had been performed with the following results:[5]

Cured,	35 cases	= 70 per cent.
Uncured,	5 "	= 10 "
Died,	10 "	= 20 "
	50 cases.	

Ages.	Cases.
1 to 10 years,	12
11 to 20 "	16
21 to 30 "	13
31 to 40 "	1
41 to 50 "	3
Over 50 "	5

The youngest was 2 years old, and the oldest 78 years old. Down to March 15, 1883, a second series of fifty operations had been performed by Schwartze,[1] which, added to the preceding, gives a table of results for 100 cases as follows:

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[1] Schwartze and Eysell, loc. cit. See also Beck, Kr. des Gehörorgans, p. 60.

[2] Lehrbuch, p. 112, 1856.

[3] Archiv f. Ohrenh., Bd. i., N. F., 1873.

[4] Ibid., Bd. vii. S. 157.

[5] Ibid., Bd. xiv. S. 202, January, 1878.

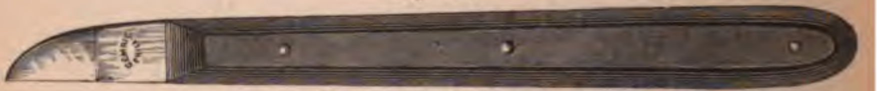
Cured,	74 cases.
Uncured,	6 "
Died,	20 "
	100 cases.

It will be seen that the percentage of cure is a little higher in the 100 cases than in the first 50, and that the percentage of deaths is the same.

Many other aurists have written upon the pathology and treatment of mastoid disease within the last ten years, among whom have been Bezold,[2] of Munich; J. O. Green, of Boston; A. H. Buck, of New York; Hartmann, of Berlin; Jacoby,[3] of Breslau, and many others. Their testimony is all in favor of the feasibility and harmlessness of the operation.

Modes of Perforating or Trephining the Mastoid.—After the patient has been thoroughly etherized, let an incision be made about half an inch behind the auricle, beginning nearly on a line with the top of the auricle. In many instances the surgeon may be surprised at the thickness of the tissues at this point, and the depth to which he must cut before the bone is touched. The bleeding will usually be quite free, but this is no disadvantage. If an arterial branch shall have been severed, the hemorrhage of course should be controlled by a ligature. The wound may then be carefully sponged and the bone examined. It may be so soft as to yield readily to the pressure of a probe or of a knife-blade. The latter should not be too long, for fear of penetrating too far with it: therefore, the kind of knife represented in Fig. 106 is preferable. It will be observed that this knife is thick, strong, and short in the blade. It may be all that is required in many cases in which the bone is softened, and it is always a safe implement.

Fig. 106.



STRONG KNIFE FOR INCISING SOFTENED OUTER MASTOID TABLE.

If, after the incision and dissection of the periosteum, the bone is found hard and resistant to pressure from a probe or the strong knife-blade, it may be opened by means of small trephines, bits, various kinds of chisels, drills, etc. The forms of instruments I prefer are those recommended by Dr. A. H. Buck, and shown in Fig. 107.

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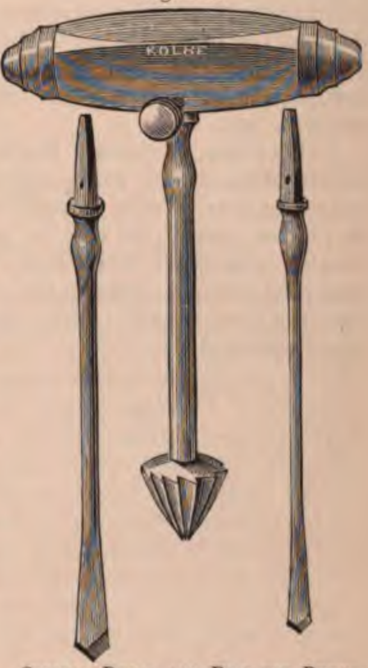
[1] Archiv für Ohrenheilkunde, Bd. xix., Heft 4, S. 217.

[2] Ibid., Bd. xiii. S. 26.

[3] Ibid., Bd. xv. S. 280.

The Point to be chosen for Perforating the Mastoid Wall.—If pus be found beneath the periosteum, an opening in the mastoid may be suspected, and should be sought for with a probe. If such an opening is found, the perforator may be applied here, and the existing hole made larger, as stated by Buck and others. If the operator may choose the point for perforating the mastoid, the instrument should be placed about a quarter of an inch behind the external auditory meatus, a little below the level of the upper wall of the canal. If the line of the zygoma and the temporal ridge be extended posteriorly, until it intersects a perpendicular drawn through the mastoid tip, the angle lying between these lines on the side towards the porus acusticus externus will indicate the position for the insertion of the point of the perforator. A few turns of the pyramidal borer, in a direction inward, forward, and slightly upward, will usually be sufficient to perforate the mastoid wall, the average thickness of which at the point indicated, is about one-fifth of an inch (Buck). The opening thus made may be further and definitely enlarged by the use of a bit, as represented in Fig. 107. Retractors, which are made of steel, will be found of service in holding the edges of the incision out of the way of the operator. They are, of course, to be intrusted to a careful assistant. After the mastoid cells are thus exposed, they may be broken up by means of a firm probe, and the antrum mastoideum thus reached. Schwartze prefers the gouge to all other implements for perforating the mastoid wall. Such an instrument may be of value in hyperostosis of the mastoid cells and outer wall, for, as Dr. Schwartze shows, by its employment the cells may be bared and even the mastoid antrum reached, by the successive removal of layers from the mastoid table.

Fig. 107.



CONICAL DRILL AND BITS FOR PERFORATING THE MASTOID PORTION OF THE TEMPORAL BONE.

Although the pain may have been intense and unyielding, and the general symptoms of the patient strongly indicative of cerebral complication, the perforation of the outer mastoid wall may not give vent to pus, but to the reddish, pulpy matter spoken of by A. H. Buck. The operation, however, gives the desired relief, and, in every probability, cuts short a process which would rapidly advance to suppuration, with all the tendencies the latter shows to force its way toward the brain. Let the operation be but honestly regarded in the light of recent investigations, and it must be admitted that it is simple, safe, and efficient.

It becomes, therefore, the duty of every conscientious practitioner of medicine to be carefully observant of the onset of an inflammation in the mastoid cavity, and prompt to relieve it; for, by so acting, he will in all probability save life, where, in similar cases, there is every reason to know that death has occurred, simply because the true nature of the mastoid disease was not recognized, and, consequently, no rational means ot relief resorted to.

SECTION VI.

DISEASES OF THE INTERNAL EAR.

CHAPTER I.

PRIMARY AND SECONDARY INFLAMMATION.

DISEASES of the internal ear are rare. They may be either primary or secondary in their origin, but those of the latter kind are by far the more frequent in occurrence. Primary affections of the ear may be considered under anomalies of formation, anæmia, hyperæmia, and inflammation. The latter may also be a process secondary to traumatic injuries which are productive of hemorrhages and other effusions into the labyrinth, and of concussion of the auditory nerve and its terminal filaments. It is also supposed, with more or less certainty, that structural changes may be brought about in the internal ear by the following diseases, viz., the continued fevers, the exanthemata, mumps, cerebro-spinal meningitis, syphilis, cerebral tumors, aneurism of the basilar artery, and, especially, by tympanic disorders.

Anomalies of Formation.—Malformations of the internal ear have been discovered in those with normal, as well as in those with abnormal hearing. These deviations from the normal standard may consist in an unnaturally large or small internal ear, or in a want of some or all of the parts of the internal ear. A want in the number of the parts of the internal ear is, however, of greater functional importance. Yet even in this respect the ear may be defective and yet not entirely deaf.[1] Rudimentary development, however, is usually found only in deaf-mutes. In a case reported by Michel,[2] and referred to by Gruber, the entire labyrinth and acoustic nerve were wanting. The facial nerve ran in an arched canal through the excessively rudimentary petrous bone.

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[1] Gruber, Lehrbuch, p. 613.

[2] Gazette Méd. de Strasbourg, 1863, No. 4.

Anæmia, Hyperæmia, and Inflammation.—Anæmia of the soft parts of the internal ear may occur in general anæmia or in wasting diseases. Without doubt, anæmia produces tinnitus aurium and alteration in the hearing. The latter may be a diminution or an exaltation of the function. In some cases presenting symptoms of general anæmia with tinnitus aurium and morbidly acute hearing, *i. e.*, an apparent hyperæsthesia of the auditory nerve, there may be a tendency to a passive congestion in the labyrinth.

More usual than the symptoms of hyperæsthesia of the labyrinth, are tinnitus aurium and dulness of hearing induced by anæmia. This peculiar state of the organ of hearing I have noticed almost entirely in chlorotic females. Sometimes in females affected with that disease, presenting as its chief features enlargement of the thyroid and other cervical glands, prominence of the eyeballs, and heart disease, deafness may be noticed as a marked symptom. Here, at first glance, one may be disposed to consider the deafness due to hyperæmia caused by obstruction to the circulation, and it may be, indeed, so induced; but the general impoverishment of the blood has seemed to me to produce changes in the labyrinth in a way similar to that in which other chronic wasting diseases effect unfavorable results in the ear.

Patients suffering with spinal disease, afflicted with pain and lying in bed for years, are not uncommonly found to be growing hard of hearing. When the spinal disease seems to be arrested, and the patient once more assumes the duties of every-day life, further loss of hearing appears to be stopped. I have been at a loss to explain these cases, unless it may be assumed that they are of a nervous nature. It must be remembered that the nerve of hearing originates from the medulla oblongata, the highly organized top of the spinal cord, and that the implication of the medulla in spinal disease may have an effect upon the nerve of hearing. How this operates I do not pretend to assert, but the cases of deafness occurring with spine diseases are not, probably, as justly placed with catarrhal affections as with nervous diseases of the ear induced by anæmia and malnutrition during the disease in the spinal column. The vertebral artery supplies the labyrinth, and this fact may also aid in explaining the occurrence of aural disease in spinal affections. In progressive locomotor ataxia it is not uncommon to find complaints made of most vexatious tinnitus aurium and morbidly sensitive hearing, or of deafness, without any symptom in the external or middle ear to account for the aural disease. It would seem but fair to refer the aural disease in such cases to the cause of the general nervous malady.

Hyperæmia of the Labyrinth.—Recent investigations respecting the histology of the tympanum and labyrinth, have shown the vascular connection between these two parts of the organ of hearing to be very intimate. It can readily be seen, therefore, how morbid processes in the tympanum may be transmitted to the labyrinth. Erhard, in 1872, suggested that even so slight a disease as a boil in the external ear, might produce secondary congestion as far inward as the labyrinth.

Politzer has traced the connection between the vascular tracts of the middle ear and those of the internal ear. This discovery tends to throw light on many morbid processes in the internal ear. It has often been surmised that disease in the tympanum had passed into the internal ear. It can now all the more surely be supposed that it does, from the facts presented by Politzer respecting the vascular relation existing between these parts. Hyperæmia of the internal ear can be explained, therefore, more clearly than heretofore, and the diagnosis of it is more rational.

Besides congestion of the tympanum as a cause of congestion of the labyrinth, may be cited other causes, either *mechanical* or *systemic*. As an example of the first, may be named the interference to the return current of blood from the head.

Among systemic causes which produce temporary congestions of the labyrinth may be named: the continued fevers, meningitis, and puerperal diseases. Not uncommonly all of the latter causes seem to produce permanent alterations in the important structures of the internal ear.

It would seem that a certain kind of congestive deafness, if the term may be used, caused by drinking spirituous liquors, may be placed under this head. Not uncommonly, patients affected with evident catarrh of the middle ear, are made to hear much worse upon drinking a glass of beer or wine. Here it may be assumed that the congestion is first in the fauces, Eustachian tube, and middle ear, and from the latter point the hyperæmia is probably extended to the labyrinth.

There is a popular impression that a drunken man is always temporarily deaf. Whether a drunken man is necessarily a temporarily deaf one, from congestion of his labyrinth, I cannot say, but I am disposed to think the function of hearing may be altered somewhat in such cases, by congestion of the middle ear, and, secondarily, of the internal ear. It is no new observation that a moderate draught of brandy or any alcoholic drink, will produce instantaneous tinnitus aurium and increase of hardness of hearing, in those affected with chronic aural catarrh. I find, in an old book by Karl Theodor Mencke, published in Hanover, in 1822, a patient's complaint of the above unpleasant result of half a glass of brandy. Intense deafness was produced, and lasted for several hours whenever he thus indulged.

Primary Inflammation of the Internal Ear.—As early as 1836,[1] Deleau pointed out the fact, that too often diseases of the ear—the middle ear, as he supposed—were mistaken for diseases of the brain. He then cites five series of observations in proof that certain peculiar sympathies may exist between the diseased ear, and the brain and other organs, as:

1. Paralysis and convulsions of the muscles of expression in the face.
2. Impairment and loss of reason.
3. Occasional but intense dizziness and cerebral malaise.
4. Frequent and intense vertiginous attacks simulating prodromes of apoplexy.
5. *Fevers may be brought on which have been termed cerebral.* In the latter instance, probably meningitis is meant by Deleau.

It seems very evident that this observer had seen many cases of aural vertigo, and of that disease so often called Ménière's.

But more definite conclusions respecting the apoplectiform symptoms attendant upon disease of the internal ear, were not arrived at until P. Ménière[2] endeavored to substantiate the following:

1. "An auditory apparatus, hitherto perfectly normal, may become suddenly the seat of functional disturbances consisting in noises of a variable nature, continuous or intermittent, and which may be accompanied, sooner or later, by a diminution in hearing.
2. "These functional troubles, having their seat in the internal auditory apparatus, may give rise to symptoms which have been considered cerebral, such as intense vertigo, uncertainty of gait, turnings to the right or left, and falling, and they may be attended with nausea, vomiting, and syncope.
3. "These accidents which are of an intermittent type, are at last followed by deafness gradually growing worse, and often the hearing is at last suddenly and totally lost.
4. "All this tends to confirm the belief that the lesion which is the cause of these functional troubles is in the semicircular canals."

Ménière's description of an aural disease, contained in these four propositions, is extremely comprehensive, but from the subsequent researches of many others, it cannot be applied to a solitary lesion in the semicircular canals. Neither are these symptoms always the result of a primary disease of the labyrinth. It has already been shown that peculiar vertiginous symptoms, closely resembling those usually called after Ménière, occur as the result of irritation in the external ear. (See p. 311.)

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[1] Bulletin de l'Académie de Médicine, Paris, vol. i. p. 234.

[2] Ibid., Paris, 1860, vol. xxvi. p. 241.

The same fact may be stated as perhaps still more commonly the result of tympanic disease. But symptoms of vertigo, nausea, reeling, without loss of consciousness, etc., with more pronounced and sudden deafness, are notoriously the result of irritation, and, in some instances, of disease of that part of the internal ear or labyrinth lying in the semicircular canals. To this may be added the fact that cerebral tumors usually produce symptoms somewhat similar to those of disease in the semicircular canals, yet distinguishable from them.

Primary inflammation of the labyrinth, if traumatic lesions are left out of the consideration, is extremely difficult to diagnosticate with certainty, and very probably is rare. There is, however, good reason for believing that primary inflammation of the internal ear does exist, and has been fully recognized.

Though, without doubt, two cases of those reported by Ménière were secondary to previous disease of the middle ear, the rest of the twelve cases showed signs of a primary lesion in the labyrinth. In the twelfth case, that of a young woman, a post-mortem examination revealed such changes in the semicircular canals, as to lead Ménière to conclude that the peculiar train of symptoms, so well known now by his name, were attributable to a lesion in these canals. But pathological foundations for substantiation of this theory are as yet meagre, though the labyrinth, in general, is looked upon as the seat of the peculiar irritation in the so-called Ménière's disease. A wider and juster term would seem to be labyrinthine vertigo, as suggested by Hinton, of London, or auditory vertigo, as suggested by Gustav Brunner, of Zurich, or aural vertigo, as I prefer to call it.

Prof. Voltolini has observed and reported some extremely convincing cases of a disease closely resembling acute meningitis in young children, but which very probably is a disease of the internal ear. From a study of such cases, a fair conclusion may be made that there is, in very young children, an idiopathic disease of the internal ear, closely resembling meningitis, but which lacks the fatal result of the latter; the patient, however, is rendered permanently deaf. This disease is called, by Voltolini, *otitis labyrinthica*. It is probably a local meningitis involving chiefly the auditory nerve. Thus, a girl, five years old, with perfect hearing, speech, and health, is suddenly attacked with violent vomiting, which lasts, with intermissions, for several days; there are also chill and fever. No cause can be assigned for the illness. On the first day of the disease the child still hears; on the second day the hearing is found to be entirely gone, but the intellect is, and *has been* from the first, clear. Signs are well understood. From the first appearance of the disease the hearing seems to be annihilated. There have been no spasms nor paralysis, and no opisthotonos. The urine and the feces present nothing abnormal. The child may cry out that the noises in the head are distressing. By the fourth day the appetite returns, and the child is found playing in bed. Upon attempting to walk, in the course of two or three weeks, the gait is unsteady, and the child must be led about. An examination of the ear reveals nothing in the sound-conducting apparatus to account for these distressing symptoms.

Such cases, in the opinion of Voltolini, "speak for themselves." "They cannot be either meningitis or cerebro-spinal meningitis, but must be regarded as a specific disease of childhood—as specific as croup."[1] Many aurists are inclined to adopt this view. The mere fact of the rare occurrence of death in the above-described disease, and the absence of important symptoms of meningitis, as well as the permanent deafness resulting, should call attention to the probability that many such cases have been erroneously called meningitis instead of idiopathic inflammation of the internal ear or labyrinth. But, in establishing the presence of such a primary inflammation in the labyrinth, great care must be taken to exclude the existence of a previous disease in the middle ear; for, doubtless, many a so-called primary labyrinth-disease is in reality secondary to a tympanic disease, as held by von Troeltsch,[2] Politzer,[3] and many others. But on this aspect of labyrinthine vertigo more will be said hereafter.

It is extremely difficult to be sure, that in every case of supposed primary lesion in the labyrinth, there has been no pre-existing tympanic disease. Until the latter can be excluded positively, it is not easy to determine that a labyrinth-disease which has manifested itself, is primary in origin. This dividing line in the diagnosis, makes these cases of so-called Ménière's disease, or aural vertigo, of greatest interest to the physician.

According to some observers, there is a hemorrhagic process, sudden and acute, occurring as a *primary* disease of the labyrinth. While such a disease may occur in the very robust and florid, as a primary labyrinth-affection, pathological evidence is so far wanting as to excite caution in making a positive diagnosis. Doubtless many cases of apparently hemorrhagic disease of the internal ear occur, as shown by Moos;[4] but he is disposed to regard even the best defined cases as *secondary* to disease of the middle ear. If, therefore, any trace of preëxisting disease of the tympanum, or of any part of the middle ear or external auditory canal, is found in connection with very manifest symptoms of labyrinthine vertigo, the latter cannot be adjudged as primary. But, if an individual in full possession of positively normal hearing, be suddenly attacked with tinnitus aurium, distressing vertigo, nausea, vomiting, and faintness, the forehead and entire cutaneous surface being at the same time bathed in clammy sweat, but the *mind entirely* clear, and if the gait be unsteady, or the ability to walk entirely gone, with more or less hardness of hearing at the outset, rapidly passing into total deafness, then a diagnosis of acute, primary inflammation of the internal ear, serous or hemorrhagic, may be made.

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[1] Monatsschrift. f. Ohrenh., 1872, No. 8.

[2] Treatise, Lect. 28, p. 516.

[3] Archiv f. Ohrenheilkunde, Bd. ii. S. 91.

[4] Archives of Oph. and Otol., vol. iii. part 1, p. 118.

Causes.—If the diagnosis of a primary inflammatory disease of the labyrinth is hard to establish, the assigning of a cause for it is perhaps still more difficult. In some instances it is evident, as in cases of violence, that the origin of the disease in the labyrinth is traumatic. Perhaps, in some cases, it is due to hemorrhage from atheromatous vessels, rendered weak by general atheroma in the circulatory system.

Treatment.—If the diagnosis of a primary inflammation, of a serous or purulent nature, can be established, the treatment should be conducted on general principles. Calomel and iodide of potassium will, perhaps, render the best aid. If the disease appear to be of a hemorrhagic nature, and the subject of it apoplectic in diathesis, then the form of treatment known as depletory should be used. Local bloodletting would be of prime importance. This might be followed by iodide of potassium or the bichloride of mercury, or by both. Here, too, in either form of the disease, is one of the few instances in which a blister over the mastoid, or in front, or about the auricle, may be of advantage. But vesication must be kept up if it is to be of service in these cases. A small, solitary blister is of no avail; it is, indeed, a positive annoyance to the patient, who should be made as comfortable as possible. But a small vesicated spot behind the auricle may be kept up for several weeks. Digitalis and nitrate of silver—but both with great caution—may be given, apparently with advantage.

Injuries.—Fractures of the base of the skull often implicate the temporal bone. The fissure may extend through the petrous portion, and involve the bony labyrinth, with its delicate and important soft contents. I examined, not long ago, the skull[1] of a young man, who in sliding on the ice fell, and, striking his occiput, fractured his skull. The line of fracture ran symmetrically through the temporal bones as follows:

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[1] Specimen C. 21; Museum of the College of Physicians of Philadelphia.

Right Side, viewed externally.—The fracture began in the squamous portion, at a point one-half inch in front of the posterior inferior angle of the parietal bone, ran across the lower part of the squama, then downward, forward, and inward, forming a curve with its concavity downward, across the upper and anterior wall of the external auditory canal, and was lost in the glenoid fissure. *Internally*, the line of fracture began at a point on the upper edge of the temporal bone where the squama fades into the anterior surface of the petrous portion, followed the anterior edge of the tegmen tympani, and ran through the Eustachian tube, in the long axis of the latter. The fracture had thus separated the anterior half of the osseous Eustachian tube from the posterior, and a portion of the anterior wall of the external auditory canal from the rest of the meatus. The two canals were thus thrown into one. The delicate septum of bone between the carotid canal and the Eustachian tube was intact.

Left Side, viewed externally.—The fracture began at a point similar to that on the opposite side, ran directly forward toward, and in a line with the zygoma, till it reached the point where the latter fades into the junction of the squama and mastoid; here the fracture ran abruptly downward and across the external auditory meatus, dividing the canal equally into an upper and lower part, and instead of losing itself in the glenoid fissure, it ran through the tympanic bone. Internally, the fracture started at a point similar to that on the opposite side, but ran much closer to the ridge of the petrous portion; it ran down through the middle of the tegmen tympani, bisecting the mastoid antrum, tympanic cavity, and the Eustachian tube, and met the line of fracture of the opposite side at the spheno-occipital suture. The horizontal semicircular canal was laid bare, but not fractured; it could be seen like an ivory coil lying in the spongy tissue of the temporal bone exposed by the fracture of the mastoid antrum. The internal ear was not fractured on either side. There had evidently been great hemorrhage, as the mastoid cells and sigmoid sinus were filled with hard and dried blood. The ante-mortem notes are wanting.

Politzer[1] has given the details of a case of fracture of the temporal bones, observed by him in a man, who suddenly fell, striking his occiput on the pavement. Unconsciousness lasted several hours; upon the return of consciousness it was found that the man could not hear nor speak. On the next day, however, the power of speech returned. In the seventh week meningitis set in, and death occurred. The post-mortem examination revealed a fissure at the base of the occiput, extending through both temporal bones, across the vestibule to the inner wall of the tympanum.

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[1] Archiv f. Ohrenh., Bd. ii. S. 88, 1865.

The soft parts of each labyrinth were disorganized; on the right side, the coagulum resulting from the hemorrhage was found nearly unaltered; on the left side, purulent metamorphosis had occurred, and from this point, pus had forced its way through the fracture to the base of the skull, and there produced a basilar meningitis, which had caused death.

Symmetrical fracture of the base of the skull, similar to this case, has been described by Voltolini:[1] A soldier was struck on the left temple by a billet of wood. He fell stunned; upon regaining consciousness in a few minutes, he vomited, complained of noises in his head, and deafness. There was no hemorrhage from the ear, nor paralysis. Cerebral symptoms supervened, and death occurred on the eleventh day after the injury. The post-mortem examination revealed a fracture extending through both petrous bones, between the round window and the cochlea. It is said that the base of the skull may be fractured; the membrana tympani ruptured; hemorrhage from the ear may take place; there may be facial paralysis on the corresponding side, and yet total recovery ensue, as shown in a case given by Dr. A. Eysell,[2] of Halle.

Symptoms.—In all works of surgery it will be found that one of the symptoms, and a very unfavorable one, too, in fracture of the base of the skull, is a discharge of serum, sometimes tinged with blood, from the external auditory meatus. The serous discharge is generally supposed to be the cerebro-spinal fluid. It is a much graver symptom than pure hemorrhage from the ear.

If the fracture has implicated the bony labyrinth, it can very readily be understood how an escape of serous fluid may occur from the external meatus. Let it be supposed that such a fracture has not only placed the internal ear in communication with the tympanum, but that the membrana tympani, or the upper wall of the auditory canal, or both, have also been fissured. Then the fluid contents of the internal ear, shown by Hasse to be part of the cerebro-spinal fluid (see pp. 138, 139) will naturally escape, and the internal ear be destroyed.

Injuries thus affecting the internal ear may be produced by penetrating violence from without, through the external auditory canal, or by blows and falls. That force known as contre-coup, often produces fracture at the base of the skull. When the force comes from below upward, as in a fall, the force of which is communicated through the legs and spinal column to the base of the skull, a fracture may occur only at the latter point, a circumscribed disk of bone being driven upward, as it were, without an extension of the fissure outward to the membrana tympani. In such cases great difficulty will be met in making an accurate diagnosis. Even when the fracture has extended to the membrana tympani and the external auditory canal, thus placing the latter potentially in communication with the internal ear, blood-clots may, for days, occlude the fissure; but sooner or later the cerebro-spinal fluid will make its appearance, in such cases, at the outer auditory meatus.

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[1] M. f. Ohrenh., 1869.

[2] Archiv f. Ohrenh., Bd. vii. S. 208, 1873.

Although it appears that fractures at the base of the skull, involving the petrous bone, may not prove fatal in every instance, the hearing is permanently destroyed by such an injury.

Mr. J. Hutchinson[1] has reported a case of fracture of the petrous and squamous portions of the right temporal bone, without laceration of the dura mater. Acute arachnitis occurred over both sides of the brain. On the day following the fall which produced this injury, there was found a watery discharge from the right ear. This observer states that inflammation of the subarachnoid space is more likely to occur than arachnitis, after injuries to the head, in which a drainage from one ear has ensued.

Another case from this observer is as follows:

A boy fell down stairs, was stunned, and bled from the right ear, and was deaf on that side. On the 2d day he was conscious but stupid; still deaf on right side. 3d day: Pulse 80, irregular; feverish; peevish and restless; tongue coated; serous discharge from ear. 4th. day: Worse; very restless; no paralysis; pupils dilated and fixed. Near midnight violent convulsion, in which he died. At the autopsy, fracture of the petrous bone was found. Lymph in the subarachnoid spaces at the base of the brain and around the pons and medulla.

SECONDARY INFLAMMATION OF THE INTERNAL EAR.

Disease of the internal ear has been, for a long time, considered a result consequent upon other diseases.

Itard names five causes of secondary changes in the auditory nerve, in all probability meaning by the latter the entire internal ear. These causes are thus given by him:[1] *Concussion of the nerve, convulsions, apoplexy, fevers, and sympathetic influence of some other diseased organ.*

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[1] Lancet, London, 1875, vol. i.

[2] Maladies de l'Oreille, Paris, 1821, p. 311.

Deafness from Concussion.—Deafness from concussion is no uncommon occurrence. The following cases will illustrate the general features of such accidents.

CASE I. Mr. R., banker, aged thirty-eight, single, stated that eight years previous he was thrown from his horse. He was made senseless for some time; upon recovering consciousness he found that he was absolutely deaf in the left ear, and he has remained so ever since. Taste and smell were greatly impaired; but they gradually returned, taste first, and then the sense of smell. The latter, however, has never been as sharp as it was before the accident. The inspection of the left external ear and membrana tympani presented nothing abnormal. The deafness was absolute.

CASE II. A young man, nineteen years old, standing on a moving railway-train, was struck on the head as the train passed under a bridge. He was picked up and carried home in unconsciousness. Upon the recovery of consciousness, it was observed that he was deaf in both ears. His family think he could hear a little when he first became conscious, but in a few days he was certainly absolutely deaf. His voice assumed a most peculiar and unnatural clang. Upon inspection of the drum-heads, it was found that they presented nothing to explain the deafness. The diagnosis in such cases is paralysis of the auditory nerve, from concussion of the labyrinth.

CASE III. A boy was struck on the external ear by a hard snow-ball. He became totally and permanently deaf on that side. The drum-head appeared normal.

CASE IV. A young druggist was standing with some friends near a party of men firing salutes on the fourth of July; while his back was turned to the guns, the discharge occurred, and he instantly observed a buzzing and deafness in one ear. This continued for some days; rest and some general tonic treatment seemed to do good, for gradually the subjective noises in the ear ceased and the hearing grew sharper and finally was restored. But these cases do not usually terminate so favorably. Whatever is done for them must be done promptly.

CASE V. An Irishman, forty years old, states that he became deaf in his left ear from an accident which happened to him while helping to lay cobble-stones in a street. He stated that that in lifting the long, heavy pounder these men use to drive the stones down, he lost his balance, and the force of the blow seemed to spend itself on the left side of his body and head. He noticed immediately that he was deaf, and he has remained so. The drum-heads presented nothing to explain the deafness, and the case was apparently one of deafness from concussion.

Dr. Brunner[1] has recorded the case of a man thirty-six years old, who fell and struck the left temple: the man lay for some time insensible; he was picked up and carried into his house, where he lay in unconsciousness all night. There was some bleeding from the nose and left ear. Upon regaining his consciousness he was unable to speak or to write, and there was paralysis of taste on the left side, the latter attributable, according to Dr. Brunner, to an injury of the chorda tympani. The power to speak and write returned in the course of three weeks. The sense of taste returned gradually in the course of four months. The hearing, at that length of time after the fall, was $\frac{1 \text{ cm.}}{150 \text{ cm.}}$ for the watch.

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[1] Archiv f. Ohrenheilkunde, Bd. vi. S. 32.

Itard states that convulsions are a rare cause of deafness in the adult, but a frequent one in infancy. When the hearing is lost in the first three or four years of life, it is generally in consequence of convulsions. A number of infants, referred to by him, had become deaf at the period of dentition, having, for the most part, ceased to hear immediately after a light convulsion. I have seen a number of mute children who were supposed to have become deaf in consequence of convulsions. Upon closer investigation, there was no history of cerebro-spinal meningitis, and I am inclined to believe that the cause assigned by the parents, "fits," was the true explanation of the destruction of hearing. Most writers are in accord that the following diseases produce secondary results in the labyrinth, *i. e.*, secondary morbid processes in the tympanic cavity: cerebro-spinal meningitis, mumps, and syphilis; typhoid, intermittent, and other continued fevers; the exanthemata, and some skin diseases about the head, as erysipelas; and the puerperal state, and its diseases.

Hardness of Hearing, and Total Deafness after Cerebro-spinal Meningitis.—Hardness of hearing and total deafness frequently occur as sequelæ of cerebro-spinal meningitis, a fact noted by all writers on the nature and course of this fever.

In an epidemic in the Philadelphia Hospital,[1] occurring in 1866–67, deafness existed to a greater or less extent in sixteen cases. In twenty-four cases observed by Fassett, referred to by Stillé, one-half recovered; but three of them with entire loss of hearing, and one with partial deafness as well as strabismus.

Dr. Knapp[2] had an opportunity of seeing seventy-one cases of deafness, and fourteen of blindness, mostly in children under ten years of age, the result of epidemic cerebro-spinal meningitis in New York, in 1872–73. He states that "the deafness or blindness was, in most cases, first noticed during the first or second week of the fever; in rare cases the deafness set in during the mostly protracted period of convalescence, and, exceptionally, even so late as *six months* after the beginning of the cerebro-spinal inflammation. In these latter cases, however, some hardness of hearing was observed when the patients had so far recovered that their hearing could be tested. The hardness of hearing then increased slowly, and terminated in complete deafness within some weeks or months."

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[1] See "Epidemic Meningitis, or Cerebro-spinal Meningitis," by Prof. Alfred Stillé, Phila., 1867, p. 61.

[2] "Deafness from Epidemic Cerebro-spinal Meningitis." Trans. Amer. Otol. Soc., vol. i. p. 448, 1873

Both meningitis and cerebro-spinal meningitis may lead to disease of the labyrinth by direct transmission of the inflammatory action. Disease of the middle ear also results from those affections, and in many cases these two parts of the ear may be simultaneously affected. But according to the observations of all, the labyrinth is the part most usually attacked by meningitis. The nature of the lesion is supposed by some to be suppuration of the labyrinth, but by others it is not thus explained, as there are not enough post-mortem proofs of such a lesion.

According to Roosa, it seems probable that the seat of the lesion is to be found in the labyrinth proper, and not in the auditory nerve-trunk, for the facial nerve is seldom affected.

Von Troeltsch is disposed to place the lesion in the fourth ventricle of the brain, from which the auditory nerve springs. (Work on the Ear, American edition, 1869, p. 511.) We learn from the work of Stillé, already referred to, that "the ventricles are the seat of effusion in many cases;" the nature of this may be serous (Stuart), aqueous (Jackson), purulent (Ames), a limpid fluid (Craig), and sero-purulent (Armstrong and Clarke), while Klebs has found the fourth ventricles and the aqueduct of Sylvius fully distended by thick yellow pus.[1]

According to the investigations of Weber-Liel and Hasse (see p. 138) it is fully established that the subarachnoid cavity and the labyrinth are in direct communication, the endo- and peri-lymph of the latter being really part of the arachnoid fluid. By this means, as Hasse justly observes, morbid processes may be communicated from the brain to the ear, or *vice versâ*. Now, it is one of the marked anatomical features of this disease that the arachnoid tunic is constantly found altered by the morbid process. Lymph and pus may be found between it and the brain, as has been fully demonstrated by many post-mortem examinations. It would seem highly probable, therefore, that in this disease the morbid process is conveyed from the brain to the ear by continuity.

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[1] Stillé, op. cit., p. 81.

In a case observed by Moos, the hearing failed on the third day; the other symptoms ceased on the ninth day, and four days later the hearing began to improve. It is stated by Moos,[1] that, in the cases, terminating favorably, reported by Ziemssen and Hess,[2] the hardness of hearing began mostly on the third day.

After a careful dissection and microscopical examination of the internal ears in a case of cerebro-spinal meningitis, which proved fatal thirty-six hours from its inception, Lucæ[3] found the hemispheres, base of the brain, pons, and medulla affected by a purulent inflammation of the pia mater. The microscopic examination traced the purulent inflammation along the auditory nerve to the cochleæ. Purulent inflammation of the sacculi, ampullæ, and canals of the membranous labyrinth was also found; along their vessels were masses of pus-cells and free blood-corpuscles; the vessels were intensely congested and much thickened; the semicircular canals also showed occasional ecchymoses. The tympanic cavities, except a slight injection, were normal. The fibres of the facial nerve were subjected to microscopical examination, and were found to be normal. In the ampullæ and sacculi were here and there deposits of fat and chalk. Lucæ concluded that it was probable the disease began first in the brain and then passed to the ear. In the same article it is stated that Heller[4] found, in a case presenting similar disorganization in the labyrinth, purulent inflammation of the middle ears.

In some cases of deafness after cerebro-spinal meningitis there appear to be lacunæ in the hearing:[5] thus, speech is heard very imperfectly, while the patient's own step and loud noises in the street are heard comparatively well. The low notes on the piano are not heard in some of these cases. This seems to indicate that parts of the terminal nerve-filaments have been impaired, while others have escaped. When some hearing still remains, hope of further recovery may be entertained if the treatment be applied promptly. This has seemed most efficacious, according to some observers, when consisting in the application of the constant electric current, according to Brenner's method.

The tone lacunæ, or gaps in the hearing, were very marked in a young man seventeen years old, whom I examined several years after his recovery from an attack of epidemic cerebro-spinal meningitis. He could not hear the voice of others, but he heard his own. He could easily perceive some sounds, as the cracking of a whip, the rolling of heavy carts past his door, etc. His voice was peculiar, and wanting in timbre, like that of the deaf-mute. His intellect was good, and his capacity for business well known. Electricity, applied in Brenner's way, effected no improvement; very probably, because applied too late.

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[1] Archives of Oph. and Otol., vol. i.

[2] Deutsches Archiv für Klin. Med., 1865.

[3] Archiv f. Ohrenheilk., Bd. v.

[4] Archiv f. Klin. Med., Bd. iii. S. 482.

[5] S. Moos, Peculiar Disturbances of Hearing after Cerebro-spinal Meningitis; considerable Improvement by the Galvanic Current. Archives of Oph. and Otol., vol. i. pp. 332-340, 1869.

The staggering gait is usually noted, only at first, in those who have been made deaf by cerebro-spinal meningitis. This sequel however may be still marked six weeks after convalescence. In walking, the gait is sailor-like, and the peculiar attitude of those on shipboard is assumed in order to steady the body. The staggering gait does not remain, however, as the absolute deafness does.

Prognosis and Treatment.—The prognosis is always highly unfavorable. The treatment, certainly in the early stages of the deafness, would naturally be the treatment carried out for the cure of the primary disease. After convalescence from the meningitis, electricity in the form of the constant current, and the administration of strychnia, either internally or hypodermatically, have been thought to be of value, if there is any remnant of hearing. But they are not usually attended with satisfactory results, and if the hearing be entirely gone, they are powerless to restore it.

Disease of the Internal Ear from Syphilis.—Although the majority of writers upon syphilis, agree that the ear is often affected in the constitutional form of that disease, aurists have not felt warranted in making such assertions, nor is it probable that the internal ear is the seat of the disease. It is far more rational to suppose that the syphilitic taint is felt first and chiefly in the mucous membrane of the middle ear.

Schwartze[1] states very justly that "the question to be decided is whether the aural diseases which occur in the course of constitutional syphilis, possess distinctly characteristic and ever-recurring anatomical and clinical peculiarities. Only by proving that such is the case can it be positively shown that a given ear-disease is of a specific nature." He further regards the recovery of an aural affection, in consequence of an anti-syphilitic treatment, as inadequate proof of the origin of the ear-disease. After considering syphilitic affections of the external and middle ear, he alludes to syphilitic disease of the nervous apparatus of the ear. Six cases are given, four of which were affections of one side only. The characters of these were, intracranial paralysis of the acoustic nerve, anæsthesia of the left acoustic nerve, in consequence of otitis interna syphilitica, and paralysis of both acustici, from double otitis interna syphilitica. Some of these cases were benefited in their hearing, by anti-syphilitic treatment, but this cannot be assumed as establishing the existence of a disease of the internal ear.

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[1] Archiv f. Ohrenheilkunde, Bd. iv. S. 253.

In many instances of deafness occurring in syphilitic patients, an endeavor has been made to establish the diagnosis of syphilitic inflammation of the cochlea. The existence of such a disease and recovery from it, cannot be proven by the acoustic phenomena presenting themselves. These may be accounted for much more easily by the supposition of altered conduction of sound, by reason of changes in the mucous membrane of the middle ear so well known to occur in syphilis, than by the difficult and entirely untenable view that changes in audition are due to alteration in the nerve, and hence are phenomena of altered perception. The fact that sudden deafness in a syphilitic patient may be cured by an anti-syphilitic remedy, is by no means a proof that the disease lay in the cochlea or in any other part of the nerve-structures in the internal ear. It would be just as much a proof, perhaps more potent evidence, that the disease had been in the mucous membrane of the drum-cavity or in that of its contents, and, by interfering with sound-conduction, had caused deafness, and that the latter had been removed by the anti-syphilitic action of the drug upon the mucous membrane. Furthermore, if in these cases an inflammation of nerve-tissue has been imagined, it is by no means clear on any ground, that the disease could be easily cured by any remedy, nor, if the disease were removed, that the hearing would return either quickly or so completely as has been asserted in the cases of so-called "cochlitis."

Symptoms, Prognosis, and Treatment.—The chief symptoms of asserted syphilitic disease of the internal ear are said to be sudden deafness, accompanied sometimes by paralysis of other parts of the body, and by vertigo, nausea, and unsteadiness of gait. Tinnitus aurium is more or less constant, and may, with sensations of fulness and beating in the ear, precede the deafness. Headache is generally complained of, the scalp being very often, in such cases, the seat of a cutaneous eruption of a more or less markedly specific nature. The prognosis is not favorable; if the syphilitic nature of the disease can be established, the treatment, of course, should be an anti-syphilitic one.

Disease of the Internal Ear from Typhoid Fever.—In some instances it would seem that the internal ear had been affected by typhoid fever. But the vast majority of cases thus diagnosticated appear, on closer investigation, to be diseases of the tympanum.

A labyrinth-affection must be considered, so far as it follows typhoid fever, as at most secondary to a tympanic disorder. As I have observed a number of neglected cases of tympanic inflammation following typhoid fever, I am led to conclude that it is in the middle ear, rather than in the labyrinth, that an aural disease after typhoid begins. A chronic aural catarrh having such an origin is as likely to be incorrectly diagnosticated as a nervous or labyrinthine disease, as it is when arising from other causes. By neglect of the tympanic disease, a labyrinthine disorder may be established. Hence, the erroneous impression that the labyrinth has been the seat of the primary affection. Treatment is of no avail in these cases.

Aural Disease in Rachitic Affections.—It is not uncommon to find rachitic subjects suffering from purulent disease in the tympanum, from symptoms of catarrhal disease in the middle ear, and from total deafness, with dumbness. The filamentous cones found by Virchow in rachitic bones have been found in the labyrinth of rachitic patients who had been deaf and dumb, and in the recessus hemiellipticus.[1] The scalæ of the cochlea in such cases may be abnormally and irregularly curved and inclined to be angular at the turns. Entrance to the round window may be narrowed to 0.5 mm., one-half the normal size. The niche for the oval window may be rendered deep by superposed bone tissue, and, the plate of the stapes disappearing, its place may be occupied by bone tissue. The entrance to the porus acusticus may be narrowed and misshapen; fibrinous coagula may be found in the cochlea, and in the acoustic nerve; the ganglion cells may be full of pigment, and exhibit the so-called knots of nerves of Ranvier. These alterations, according to Moos, may be congenital or acquired. Under the first head may be found imperfect ossification of the stapes, absence of its foot-plate, while the original club-shape of the whole undeveloped bone is maintained. In such cases there is also found imperfect ossification of the facial canal.

Under acquired alterations, the same observers have placed hyperostosis of the tympanic walls with consequent deepening of the fenestral niches, and impairment of the hearing. Also contraction of the internal porus acusticus, and transformation of the annular ligament of the stapedial foot-plate into bone, thus demonstrating the occurrence of rachitic processes in the temporal bone.

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[1] Moos and Steinbrügge, Archives of Otology, vol. xi., 1882.

AURAL VERTIGO.

Aural or auditory vertigo, as its name would indicate, is a vertiginous condition due to an irritation of the auditory apparatus. This irritation, usually in the form of pressure, may be situated either in the external, the middle, or the internal ear, or in or upon the auditory nerve, within the cranial cavity. Though originating in the different parts of the organ of hearing, this irritation, in order to produce vertigo, must be exerted ultimately in the form of pressure upon the terminal filaments of the auditory nerve in the semicircular canals, and thence conveyed to the cerebellum, as will be shown hereafter. Some observers hold that all disturbances in equilibration, as manifested in giddiness, are due either to a temporary or a permanent lesion in the labyrinth. In fact, some hold that the semicircular canals are vertiginous centres. While I am not prepared to accept this theory, it is plain to my mind that in the semicircular canals there is found a very sensitive medium of communication of impressions to the cerebellum, and hence that these canals may be considered as in many respects presiding over the equilibrium of the body. Although many instances of vertigo can be shown to be due to irritation of these canals, by virtue of the vaso-motor connection between them and remote parts of the body, it is my object to limit the scope of this paper to a consideration of vertigo arising from irritation in the various parts of the auditory apparatus, and communicated to the semicircular canals, and thence to the cerebellum. The whole matter of aural vertigo will be most easily understood by a consideration, first, of the structure and distribution of the auditory nerve.

Structure of the Auditory Nerve.—M. Duval has shown[1] that a portion of the fibres of origin of the auditory nerve are closely connected with a mass of motor-cells in the bulb, and that these fibres pass into, and are continued in, the inferior peduncles of the cerebellum. The inferior peduncles of the cerebellum connect it with the medulla oblongata, pass on downwards to the back of the medulla, forming part of the restiform bodies, and are then connected below with the corresponding half of the cord, excepting the posterior median columns.

It is well known that injuries of these peduncles cause disturbances in motion similar to those observed after lesions of the semicircular canals. It seems, therefore, that there is a sort of special function resident in these canals, that exaltation of their function evokes peculiar movements of the head and mediately of the trunk and limbs, and that the anatomical explanation of this is found in their cerebellar connection. It further appears that there are two kinds of fibres in the auditory nerve, viz., the motor fibres, distributed to the ampullæ of the semicircular canals and connected with the bulb and the inferior peduncles of the brain, and another set distributed to the utriculus, the sacculus, and the cochlea, which are accepted as purely sensory. It is to the motor set of fibres in the acoustic nerve that our attention must be directed in considering the subject of aural vertigo.

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[1] Gellé, de l'Oreille, etc. p. 323. Paris, 1881.

The question naturally arises, Are not these inferior peduncles wounded in experiments on the semicircular canals? The reply is that in the pigeon, used for these investigations, the semicircular canals stand away from surrounding tissues in the cranium, as the cochlea does in the bulla of the guinea-pig, so that the mutilation of any parts but the semicircular canals is avoided. That the phenomena attributed to mutilation of the *semicircular canals* in these experiments are justified seems further confirmed by recent experiments by Gellé, of Paris, upon the *cochlea* alone, by which he shows that in the guinea-pig mutilation and extirpation of the cochlea, easily accomplished in this animal without opening the true cranial cavity, is unattended by the slightest disturbance in equilibration.

It must be further borne in mind that the auditory nerve originates from numerous white striæ—the lineæ transversæ—which emerge from the floor of the fourth ventricle, and that it is also connected with the gray matter of the medulla. Now, the fibres of the pneumogastric nerve may be traced deeply through the fasciculi of the medulla, to terminate in a gray nucleus near the floor of the fourth ventricle; so that, anatomically, the auditory nerve and the pneumogastric are thus shown to be at least contiguous at their origin—a fact entirely satisfactory in the "overflow" theory, as will be shown.

As has been said already, authors speak of a "vertiginous centre,"[1] and of vertigo as "undoubtedly a sensation." The latter may be evoked by an overflow of nerve-impulse from some one centre of the encephalon, to the so-called vertiginous centre; and, from what we know of the physiology of the semicircular canals, we may assume that the central termination of the ampullar nerves is in very close connection with a spot in the brain, irritation of which will produce the sensation of giddiness. This, as we now know through the labors of Duval, is in the cerebellum, and owes its great influence most probably to its connection, by means of its inferior peduncles, with the spinal cord.

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[1] P. McBride, of Edinburgh, Medical Times and Gazette, vol. i., 1881; also J. A. Irwin, M.A. Cantab., M.D. Edin., Pathology of Sea-sickness, Lancet, Nov. 25, 1881.

To this connection we owe the greater or less impulse conveyed over the portion of the auditory nerve supplying the semicircular canals in every turn of the head or movement of the body. When this impulse is slight, or let us say normal, it does not produce vertigo, but informs us, or aids in the information, of our position in space. Thus there is established the so-called "sense of equilibrium." The disturbance of this sense constitutes vertigo.

If such an "overflow" of irritation can take place between the central termination of the ampullar nerves—*i. e.*, the nerves of the semicircular canals—and the vertiginous centre in the cerebellum, it is fair to assume that a similar "overflow" may take place between this ampullar centre and the pneumogastric centre, simply because the two latter are more contiguous to each other than the ampullar centre and the vertiginous centre in the cerebellum. In this contiguity is found an easy explanation of the nausea, vomiting, pallor, and faintness, the slow breathing and weak pulse, which occur in aural vertigo; for we are entitled to assume that the irritation in the auditory apparatus and auditory nerve-centre overflows to the respiratory, the cardiac, and the vomiting centre.

Symptoms.—The symptoms of aural vertigo may be briefly stated as follows. The patient more or less suddenly experiences in one or both ears, tinnitus and more or less hardness of hearing. This is quickly followed by dizziness passing rapidly into a pronounced vertigo, with reeling and falling, accompanied by nausea, vomiting, and faintness, but rarely with loss of consciousness. When the latter ensues, it is simply complete syncope from the nausea and vomiting. Usually the patient almost instinctively associates his vertigo and attendant malaise with derangement in the ear, which may or may not have been previously diseased. These symptoms, which are here given in the order of their onset and sequence, are subject to modifications according to the part of the ear affected. Thus, when the irritation is in the *external ear*, neither the tinnitus nor the deafness may be excessive; but both are permanent from the onset to the cure, and the tinnitus is acoustically of the uninterrupted quality. When the irritation lies in the *middle ear*, the symptoms are likely to be paroxysmal, as though the physical conditions upon which the altered and morbid pressure or tension depends, varied with the state of the atmosphere or with the health of the patient. In cases dependent upon irritation in the *internal ear* or labyrinth, all the symptoms are usually more pronounced, though the attacks of tinnitus and dizziness are paroxysmal, while the deafness is most profound and permanent, whether it comes on suddenly with the first attack of vertigo or not. The latter passes off, but the deafness remains.

Vertigo dependent upon a tumor in or upon the auditory nerve, and which may be denominated a central form of auditory vertigo, is usually not paroxysmal, the patient experiencing a constant and increasing tendency to alterations in gait, with a disposition to fall towards the affected side in walking. Here the permanency of the symptoms should lead us to suspect disease in the cranial cavity.

Differential Diagnosis.—All the forms of aural vertigo are not only confounded in diagnosis with one another—and in some cases there may be a commingling of forms in the same subject—but they are constantly mistaken for stomachic vertigo, so-called biliousness, epilepsy, and even apoplexy. The confusion among the various forms is hardly to be wondered at, but the aural symptoms and the usually retained consciousness should make the differential diagnosis between this disease and others just mentioned very easy. Then, too, the absence of spasm, and the marked pallor in the patient should lead away from the diagnosis of either fits or apoplexy. This defective diagnosis has led to a faulty nomenclature, so that the term Ménière's disease, which, if it means anything, means a disease of the semicircular canals only—*i. e.*, a disease of the internal ear—has been very erroneously used to designate aural vertigo in general, instead of being limited to the form of aural vertigo dependent upon disease in the aforesaid canals. That this term, "Ménière's disease," should be thus restricted will, I think, be evident after a closer examination of all the forms of aural vertigo, of which Ménière's disease is clearly only one.

That form of aural vertigo due to irritation in the *external ear*, may be considered the simplest form of the disease, so far as concerns its production and cure; but the mode of its action is the same as in other and graver forms; *i. e.*, the pressure and irritation are at last conveyed to the cerebellum, and then the vertigo is evoked.

Illustration.—Doubtless all are familiar with the celebrated case of external ear-vertigo and other reflex phenomena associated with it, recorded by Fabricius Hildanus. In this instance, a young girl, 18 years old, is said to have exhibited, besides the ear-vertigo, atrophy of one arm, epileptiform symptoms, and even anæsthesia of one-half of the body, all of which were cured by the removal of a glass bead or ball from the external auditory canal, where it had lain for eight years. This case is not only classical but highly instructive, but in this latter respect no more so than numerous cases of tinnitus aurium, vertigo, and nausea due to the presence of foreign bodies as simple as masses of hardened ear-wax in the auditory canal, and occurring in the experience of most physicians. Vertigo due to irritation in, or applied to, the external ear and outer surface of the drum-head is also constantly seen in syringing the ear, sometimes when done ever so gently. Here the mode of irritation in most cases is by pressure upon the drum-head, and mediately by means of the ossicles and the labyrinth-fluid upon the filaments of the auditory nerve in the ampullæ of the semicircular canals, the anatomical reasons for which have already been presented.

The giddiness, however, induced by suddenly injecting cold water into the external auditory canal cannot be altogether explained by the pressure it exerts on the drum-head and mediately upon the ossicles of hearing, the labyrinth-fluid, and the cerebellar branches of the auditory nerve found in the ampullæ of the semicircular canals. Here an explanation must be sought for in the nervous connection between the external ear, the seat of the irritation, and the vertebral artery which supplies the circulation in the labyrinth. We must bear in mind that the effect of irritation in a vaso-motor nerve-tract is to excite vessel-dilatation in a correlated area, through diminished inhibitory nerve power. In this instance the irritation is the sudden presence of cold water in the external auditory canal, the diminished inhibitory nerve power is felt in the vertebral plexus, and the correlated area is the labyrinth and especially the semicircular canals. The morbid impression caused by the cold water is conveyed by the auricular branch of the pneumogastric nerve, found in this part of the ear, to the *inferior cervical ganglion*, to which the vagus sends a branch. From this ganglion the irritation is deflected to the vertebral plexus, into the formation of which, fibres from this lower cervical ganglion enter largely; the inhibitory power of the plexus is overcome, and vessel-dilatation ensues in the vertebral artery. This causes an increase in the blood-supply to the labyrinth, and the latter is in a measure engorged, and the labyrinth-fluid, having no adequate means of rapid escape, is compressed within its bony cavity. This compression is, of course, quickly felt by the nerve-filaments in the ampullæ of the semicircular canals, they are compromised, and vertigo ensues, for anatomical reasons already given.

Thus it is shown that external ear-vertigo is produced in two ways, viz., either mechanically by direct pressure on the drum-head and the chain of ossicles, or reflectively through the nervous system.

Middle Ear-vertigo.—When we come to consider aural vertigo caused by disease in the middle ear, we approach a much more complicated subject. Here the pressure and consequent mechanical irritation may be conveyed in various ways to the labyrinth-fluid and the terminal filaments of the auditory nerve in the semicircular canals, and thence by the motor fibres to the cerebellum. The most frequent mode of irritative pressure is exerted by an accumulation of fluid, mucus, pus, or serum in the tympanic cavity. The pressure is conveyed through the foot-plate of the stirrup-bone or through the membrane of the round window, or through both, to the labyrinth-fluid, and through the latter medium to the auditory nerve, which, as I have stated, contains motor filaments, and thus to the cerebellum. In fact, this process of conduction of irritation is but an exaggeration of the mode of the mechanism of hearing; and we can very easily understand how a great noise, or any noise at times, may produce dizziness and other cerebral disturbance.

Again, morbid pressure may be exerted from the middle ear upon the deeper parts of the auditory apparatus concerned in the production of ear-vertigo, by closure of the Eustachian tube, in throat- and nose-disease. After this closure of the tube, the air shut in the tympanic cavity is soon absorbed, a vacuum is then formed in the drum-cavity, and the external air presses the membrana tympani inward, carrying with it the malleus and the rest of the chain of bonelets. Thus the labyrinth-fluid is unduly compressed, and, as in the previous case, the auditory filaments in the semicircular canals are also compressed and the cerebellum irritated. In some rare instances there seems to be reason to suppose that a tonic contraction of the tensor tympani muscle occurs,[1] and that retraction of the membrana tympani and the chain of ossicles ensues. In this way the foot-plate of the stapes is forced inward through the oval window, upon the labyrinth-fluid, and cerebellar irritation is produced, as heretofore described. The attacks of aural vertigo of this latter form are paroxysmal, and are accompanied by so-called "variable hearing,"[2] the hearing growing worse as the tinnitus, which is the prodrome, increases, and finally ushers in the vertigo. In fact, any undue loading of one or of all of the ossicles, or any abnormal pressure upon them, or even excessive swelling of the mucous membrane covering them, by forcing them inward, or by carrying only the stirrup abnormally inward, would tend to compress unduly the labyrinth-fluid, especially if at the same time the swelling of the mucous membrane extends to the round window and prevents the compensatory yielding of its membrane to the inward pressure of the stirrup. In this way the vertigo so often present in acute otitis media may be explained.

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[1] See article on "Variable Hearing," by the author, in report of Section of Otology, International Medical Congress, Philadelphia, 1876.

[2] The late Mr. James Hinton, of London, in "Questions of Aural Surgery."

Middle ear-vertigo from *chronic* disease in the tympanum is very common. This source of vertigo is to be expected when we reflect that there is a direct communication between the circulation of blood in the middle ear and that in the labyrinth. Politzer has shown that the capillary bloodvessels of the tympanum pass directly through the inner or labyrinth wall of the tympanic cavity to the vestibule and other parts of the internal ear. Hence it is easily seen how disturbed circulation, which must ensue in chronic disease in the walls of the tympanic cavity, may be felt in the internal ear; and as disturbances in circulation, by altering the pressure in the labyrinth, especially in the semicircular canals, produce vertigo, it can be shown how chronic middle-ear disease may thus induce aural vertigo.

In middle ear-vertigo, it may also be assumed that the pressure in the labyrinth may at times be brought about by altered circulation due to reflex influences, as was shown in external ear-vertigo. The path of the irritation in this case, however, lies probably between the vertebral artery, the vertebral plexus, and the inferior cervical ganglion on one side, and the otic ganglion on the other.[1]

Internal Ear-vertigo.—In considering ear-vertigo due to disease in the internal ear, we approach at once the most difficult and the most interesting form of the disease under consideration. It may be produced by disease in the auditory nerve or in any part of the labyrinth except the cochlea. From recent experiments of Gellé, of Paris, it is conclusively shown that laceration and destruction of the cochlea in mammals (especially in rodents) has no effect whatever upon equilibration. This renders it more probable that the semicircular canals are the seat of the organ of equilibration.

Up to this point we have considered the effect on these canals of irritation originating elsewhere and communicated *to* them. Now we shall consider the phenomena of disturbed equilibration due to disease arising *in* them and the irritation it conveys to the cerebellum; and under this head we shall also consider the phenomena of disturbed equilibration due to irritation in or upon the auditory nerve before it reaches the labyrinth, as is sometimes found in tumors, either in the nerve or lying upon it. The phenomena in the latter case appear to be confirmatory of the existence of intimate connection between the auditory nerve-fibres and the cerebellum, by means of the inferior peduncles of the latter.

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[1] The *tympanic nerve* communicates with the *small petrosal*, a branch from the otic ganglion. The otic ganglion communicates with the superior cervical ganglion, and this with the middle cervical ganglion, if present; if not, with the inferior cervical ganglion. The inferior cervical ganglion supplies largely the vertebral plexus, regulating the supply of blood in the labyrinth.

Clinical History and Symptoms.—In internal ear-vertigo, the ear having been previously healthy, or considered so, the patient is suddenly attacked by tinnitus, vertigo, nausea, reeling, and falling, but his consciousness is retained. After these symptoms abate and the alarm of the patient subsides, the hearing is discovered to be gone in the affected ear. This form of ear-vertigo the writer has seen in adults of various ages, usually in men over thirty, and in all grades and avocations—in the hard-worked physician as well as in the over-worked mechanic. Upon examination, the drum-head will present no great change, or it will look like one belonging to an ear previously the seat of chronic catarrh; and generally, upon close inquiry, it will be elicited that there is history of exposure, in camp or in daily labor, to inclement weather, and that the ear now attacked so severely has already, at times, felt stuffed and deaf, but that it got better and remained a good and serviceable organ. The general health will be found to have recently failed, or to have been greatly taxed by some sudden stress of work, and it will also be found that the ear has "buzzed a little of late," but not constantly, and that this had been forgotten, until the attack of ear-vertigo brought it back to the memory. The hearing will be found to be profoundly impaired, and to remain so, while the tinnitus may or may not remain, and the vertigo will be found to have temporarily vanished. Sometimes, with care and proper management, no further attacks of vertigo are felt; but the hearing remains permanently affected. On the other hand, the tinnitus may be always present to some extent, may increase suddenly at times, and form, as it were, a forerunner of subsequent attacks of vertigo.

As I have rarely seen a case of internal ear-vertigo without conclusive evidence of a previous chronic catarrhal disease in the middle ear, with necessarily great changes in nutrition and circulation, and as it is fully established that the circulation between the middle and internal ears is most closely connected, therefore, I am forced to conclude that internal ear-vertigo, or "labyrinthine vertigo," is usually preceded by pathological changes in the circulation of the middle ear, which induce changes in the vessels of the internal ear, culminating in the sudden and grand attack just described. Whether these changes and their results are of an apoplectiform nature cannot be discussed here.

The diagnosis, however, will be aided by the suddenness of the tinnitus, vertigo, and deafness, and especially by the fact that the tinnitus and vertigo are more or less evanescent, while the deafness is profound and permanent from the first. This form of aural vertigo, and no other, may justly be termed "Ménière's disease."

Central Ear-vertigo.—There is a form of ear-vertigo which is due to a tumor of the auditory nerve (p. 536). When the vertiginous symptoms dependent on the presence of such a tumor, usually fibrous or sarcomatous in nature, first show themselves, it is not easy to distinguish between this form of ear-vertigo and that due to chronic changes in the middle and internal ear combined. There are, however, some points of difference so constant in their occurrence as to constitute truly pathognomonic symptoms. To begin with, central ear-vertigo dependent upon morbid growths in the auditory nerve, is never sudden, but slow in its onset. The deafness and tinnitus, as well as the vertigo, are comparatively slight at first, but then steadily increase, and are always permanent from the time they first show themselves until the end. The gait is permanently altered, though it may be only slightly changed at first, and the tendency is to fall towards the affected side. Not so, however, in true internal ear-vertigo, in which the initial lesion is in the labyrinth, in or very near the semicircular canals. In this form of disease the deafness is sudden, profound, and permanent, but the giddiness and falling are paroxysmal. In middle ear-vertigo, in which the deafness and tinnitus are great, the deafness is not sudden nor profound, the vertigo comes in attacks, and there is no permanent alteration in gait.

Apparent Motion during the Vertigo.—During the vertigo, objects may appear to revolve in an antero-posterior direction, in a vertical plane. There may be total loss of equilibrium, but perfect consciousness. The attacks may come and go suddenly, and be followed by a cold sweat.

It is very interesting to note the various planes of the apparent motion experienced by a patient during attacks of vertigo, and the length and character of the arcs of the apparent meridians described, both by the patient's body and surrounding objects. The attacks of vertigo, always accompanied by perfect consciousness, may be characterized by an apparent motion in a vertical plane from in front, backwards, *i. e.*, in the plane of the superior semicircular canal. Or, the apparent motion may be in the plane of the horizontal or inferior semicircular canal. The apparent motion may be felt even when the patient closes his eyes, a clinical fact entirely in harmony with the experimental observations of Mach (p. 149). At the time of the attacks of vertigo, the apparent or subjective motions of the patient's body may cease when he lies upon his back, although the apparent motion of surrounding objects may continue. The paroxysmal nature of the vertigo, with temporary increase of the tinnitus, in an already diseased ear, would seem to indicate that whatever the cause of the irritation is, it is not constant nor totally destructive of the part chiefly attacked. Such cases present a collection of clinical phenomena, partly of a subjective nature, most strikingly in accord with the recent investigations of Mach, Breuer, Cyon, and Curschman, all of which have added facts tending toward the conclusion that, although the semicircular canals may not be devoid of acoustic functions, they seem to possess well-marked features of presiding over the pose of the head, and *mediately* over that of the entire body (pp. 149 and 151). Those who suffer as described above may finally recover from the liability to be attacked by vertigo, but they remain totally deaf in the affected ear.

Treatment of Aural Vertigo.—If it has been shown that aural vertigo is due to pressure in some form, either directly or mediately, upon the auditory nerve, and reflexively thence to the cerebellum, the indication in treating such cases is to remove, or at least diminish, this pressure; and this can be done surgically or medicinally. Great confusion arises when these cases of aural vertigo are treated as cases of biliousness—a much too frequent error. If the irritative pressure is due to a foreign substance of any kind in the auditory canal, it is to be relieved by the removal of the foreign substance, best accomplished by syringing with warm water.

If the irritation is due to pressure from matter accumulated and retained in the drum-cavity, it must be allayed by removal of the retained mass. This can be accomplished by paracentesis of the drum-head, by inflation of the tympanic cavity with Politzer's air-bag, and by catheterization. Even when matter is inspissated in the drum-cavity, one or all of these methods combined must effect its removal. The ossicles are thus allowed to swing freely, the stirrup comes back to its normal position, the membrane of the round window is relieved, and the pressure is taken from the labyrinth-fluid and the ampullar nerves in the semicircular canals.

If the pressure is due to a vacuum in the drum-cavity, and a consequent indrawing of the drum-head and the ossicles from closure of the Eustachian tube at its faucial end, the introduction of air by one or both of the above means will usually restore the drum-head to its proper place and unlock the pressed-in chain of bonelets, thus relieving the compression in the labyrinth and semicircular canals.

In cases of tonic spasm of the tensor tympani muscle, the attacks may be relieved by inflation of the drum-cavity, which forces outward the drum-membrane and the malleus and antagonizes the indrawing effects of the spasm in the tensor muscle. The disease in this form is also to be combated by antispasmodics, preferably bromide of potash in large and frequent doses, as much as ten to fifteen grains every fifteen minutes being given, with most excellent effect, as the attacks are coming on, or during them.

When the vertigo is due to chronic aural catarrh, *i. e.*, chronic change in the mucous membrane of the middle ear, the field of treatment becomes indeed a wide one. The catarrh of the mucous membrane of fauces, nasopharynx, and nares will usually require treatment, as well as the mucous membrane of the cavity of the drum; but in these cases the greatest benefit may accrue from the use of tonics and bromide of potash as above advised.

The morbid circulation which very probably underlies these cases, may be connected with anæmia or plethora, and the diagnostician must bear this in mind in the treatment of the case. Local treatment in the external auditory canal, in this form of the disease will usually increase the dizziness by overloading, physically, the membrana tympani. Blisters, leeches, etc., about the external ear and mastoid portion of the temporal bone are useless; they may be so bothersome as to increase the malady. Rest in bed is absolutely essential when the vertigo is frequent and severe. It is always a relief during an attack of dizziness. The vertiginous centre may be said thus to recover itself, and the immediate attack is found to pass off more quickly than if the patient continues to walk about, and the liability to subsequent attacks is diminished. This is not the case, however, if the vertigo is constant and apparently due to a cerebral tumor in or about the auditory nerve or labyrinth.

Respecting the treatment of internal ear-vertigo, it may be said that a typical case of this form of the disease presents deafness which is irremediable. The attacks of tinnitus and dizziness may be lessened in number by attention to the general health, preference among drugs being given to quinia, strychnia, and iron, separate or combined. For immediate relief of the tinnitus nothing has been found by the writer equal to bromide of potash, and, in fact, no internal remedy is equal to this in relieving tinnitus generally.

Finally, the tinnitus and dizziness may cease, never to be felt again, but the deafness remains, being probably due to an organization of an exudation or extravasation thrown into the labyrinth at the time of the first grand attack. But, unfortunately, the pathological processes in such cases are not well known, as the researches have been meagre. If the case is seen at the beginning of the disease, and there is reason to surmise the existence of an exudation, an extravasation, or a hemorrhage into the labyrinth, the administration of the iodide of potash or of mercury, or both, would certainly be indicated; but, given late in the disease, these are valueless. The greatest care should be taken to build up rather than break down tissue; for there is generally in these cases of supposed exudative disease ample ground for the belief that, in overwork, a minute vessel in the labyrinth has ruptured or that a passive exudation has occurred from the walls of several vessels.

In conclusion, the following facts should be recalled to mind:

1. That there are two sets of fibres in the auditory nerve, viz., the sensory and the motor.

2. That the motor filaments are connected on one side with the cerebellum by means of the inferior peduncles, and on the other side with the nerve-filaments sent to the ampullæ of the semicircular canals.

3. That irritation of these ampullar nerves may be conveyed from either of the three parts of the auditory apparatus, or from the auditory nerve itself, in the mechanical form of pressure, and that this irritation may be further conveyed to the cerebellum and cause vertigo: so that it logically follows that this reflex cerebellar phenomenon as produced by aural irritation should receive the general denomination of *aural vertigo*, and that Ménièré's disease is only a form of aural vertigo. Hence the latter name, unless used after accurate diagnosis of a disease originating in the labyrinth, *i. e.*, in the semicircular canals, will create confusion. But it should be said, in justice to Ménière, that, so far as the writer knows, he has never claimed a general application of his name to all forms of aural vertigo. It has been so applied only by well-meaning but inaccurate diagnosticians.

CHAPTER II.

MORBID GROWTHS OF THE AUDITORY NERVE.

THE auditory nerve is more frequently the seat of morbid growths than any other cerebral nerve, as shown by Virchow. Such formations are usually of a fibrous or sarcomatous nature; the nerve may also undergo amyloid degeneration.

Fibrous Tumors.—Fibrous tumors of the auditory nerve may be idiopathic in origin, but more usually they are found in connection with caries of the temporal bone (Gruber). Such growths have also been described by Landiforth and Lévêque-Lasource, as stated by Moos.[1]

Boyer[2] describes a case of what was termed by him "cancer of the occipital fossa." In this instance the morbid growth invaded and destroyed the auditory nerve, as it did most of the nerves distributed to the right side of the head. The subject was a man, 33 years old.

Carré[3] observed a case of what he termed cancer of the annular protuberance (pons Varolii) in a man 29 years old; the hearing was diminished. At the post-mortem examination, the auditory nerve was found pressed upon, but not destroyed.

Sarcoma.—Cases of sarcoma of the auditory nerve have been observed by Voltolini and Förster.[4] In the case given by the former, a sarcoma filled the entire left internal auditory canal, and the auditory nerve was destroyed. In the case observed by Förster, a sarcoma as large as a goose's egg had sent off a peg-like process into the left internal auditory canal, which was enlarged.

Other cases presenting more or less striking symptoms of sarcomatous growths in the auditory nerve, have been recorded by Cruveilhier,[5] Moos,[6] and Boettcher.[7] The latter denominated the growth observed by him, fibro-sarcoma.

Symptoms.—It would appear from the published accounts of the occurrence of this form of cerebral tumor that it is found most frequently in females. The ages of those affected vary from seventeen to forty-nine years. The duration of the disease, counting from the earliest symptoms, may extend over seven or eight years; though it may run its full course in a year, as shown in a case recorded by Moos. The cause of this disease of the auditory nerve has been supposed to be due, in some cases, to exposure to cold; but the most frequent causes, as stated by Virchow, are mechanical injuries to the head and syphilis.

The earliest and most striking symptoms are tinnitus aurium and failure in hearing, with more or less dizziness; these are followed by greater deafness, increased noise and distress in the head, and dizziness on motion, with consequent uncertainty of gait. Then there may come a period of relief and apparent recovery from most of these symptoms, excepting the hardness of hearing. But, sooner or later, all the above symptoms return and become aggravated; the power of controlling the limbs, both upper and lower, fails; pain in the head is intense and lasting; the dizziness grows worse; the patient walks with legs apart, inclining to one side in walking; and nausea and vomiting may occur. In some cases, facial paralysis occurs quite early in the disease, and there may be anæsthesia of the mucous membrane of the nose, as noted by Moos. Not uncommonly there are symptoms of chronic aural catarrh in the ear corresponding to the side on which the auditory nerve is invaded; and this has often misled in making a diagnosis. Finally, the general nutrition of the patient begins to fail; the strength goes; diarrhœa may supervene; or the patient may sink into coma, and die with or without convulsions.

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[1] Archives of Oph. and Otol., vol. iv., 1874.

[2] Bulletin de la Société Anatomique, 9 série, 1834, p. 273. [3] Ibid., p. 115.

[4] Würzburger Med. Zeitschr., 1862; see Moos, Archives of Oph. and Otol., p. 484, vol. iv.

[5] Anatomie Path., livraison 26; see Kramer, "Die Erkenntniss, etc. der Ohrenh.," 1849, p. 858.

[6] Loc. cit. [7] Archives of Oph. and Otol., vol. iii. pp. 134–171, 1873.

Through the kindness of Dr. Morris Longstreth, Pathologist to the Pennsylvania Hospital, I have had the opportunity of consulting the ante-mortem notes, and of aiding in the post-mortem examination, of the following case of *tumor of each auditory nerve:*

Catharine C., admitted to the medical wards of the Pennsylvania Hospital on October 12, 1874. An American by birth, but of Irish parentage; forty-two years old; single, and a seamstress. Has always been well until within a year of her admission to the hospital, when she took a severe cold in the head. She also began to have at this time pain in her forehead and vertex. In the previous June her hearing began to fail rapidly, until she became very deaf. Then there supervened tinnitus aurium, *unsteadiness in gait*, pain in her limbs, impairment of sensation in the legs, vertigo, and occasional nausea. There had never been any loss of power in the limbs, nor muscular trembling.

On Nov. 1st, when Dr. James H. Hutchinson[1] took charge of the ward, it was noticed by him that there was a tendency on the part of the patient, when walking, to fall forward and to the right, and that on some occasions she had fallen. Attacks of vertigo could be induced in the erect position, by closing her eyes; but she was free from them when lying in bed. There was great pain in the head, generally referred to the vertex and to the forehead over her eyes. The tinnitus aurium continued very intense and annoying; it was, however, paroxysmal, *being worse in the morning.* There was nausea, but no vomiting.

There was no loss of power in the limbs, nor paralysis of any of the cranial nerves, and no disturbance of sensibility at that time, as noted by Dr. Hutchinson. She was deaf, but not absolutely so. There was no history or suspicion of syphilitic taint. The physical condition of the Eustachian tubes and tympana was found, by Dr. R. M. Bertolet, to be normal.

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[1] See Phila. Med. Times, May 8, 1875.

The ophthalmoscope revealed, in the *right eye*, "indistinct outline of disk; *left eye*, changes more marked, viz., outline of disk obliterated, veins much enlarged and curved at margin of disk, which is redder than normal, vessels not usually seen being distinctly visible toward its outer side."

The subsequent history of this woman shows that she was deafer at some times than at others; the right ear was better than the left (post-mortem examination revealed on the left auditory nerve the larger tumor); there were headache, falling, with inability to rise, loss of power to assist herself, and, finally, confinement to bed. There then ensued loss of power over legs, failure of intellect, and difficulty in swallowing. Muscles of eyeball prolapsed; pulse and respiration increased in frequency; cyanosis of face; involuntary evacuation of urine. Disks of both eyes became indistinct in outline; there was impaired sensation of extremities; unconsciousness and death supervened. Temperature, a few hours before death, 106° F.

Two hours after death, an examination was made by Dr. Morris Longstreth, to whom I am indebted for the following notes:

The thoracic and abdominal viscera were normal, in general; the only point to be noted was marked congestion of lung, with a small area of pneumonia in left lower lobe. Only one kidney was found, the right one, weighing nine and a half ounces. The cranium was normal, except the conditions noted below in relation to the internal auditory meatus and jugular foramina. Dura mater was normal, excepting two small spiculæ of bone in the neighborhood of the falx cerebri. Arachnoid membrane normal. Pia congested. Cerebral convolutions were flattened, especially at convexity. At the base, the floor of the third ventricle was bulging downwards and fluctuating.

On the left side, behind the petrous bone, below the tentorium, was a large tumor, pressing on the left hemisphere of the cerebellum, left half of pons, and left crus cerebri. The nerves springing from the left side of the medulla oblongata, passed on the under surface of this tumor, were flattened by it and somewhat adherent to it. The seventh nerve (auditory and facial) wound inward, forward, and then downward around the tumor, to which it was tightly adherent, and by which it was flattened into a ribbon-like band, appearing transparent. The two divisions of this nerve could not be separated without destroying them, as their consistence was so much reduced. This tumor measured two inches transversely; one and three-quarter inches antero-posteriorly. It was lobulated, and made up of cysts with solid intervening structure-like partition. Some portions were reddish or pinkish (cystic); other parts white, firm, and opaque.

This tumor extended with the eighth nerve into the left internal auditory meatus, which was considerably widened. The nerve ran along the forward and inner part of the canal, whilst the projection from the tumor-mass was on the outer and back part of this passage. In the removal of the brain the left nerve with the tumor was cut through at the surface of the petrous bone, thus separating part of the tumor and leaving it within the internal auditory canal. After removal of the brain, there was quite unexpectedly found a *second* tumor, resting on and adherent to the posterior surface of the *right* petrous bone. It was oval in shape; five-eighths of an inch long, extending along the bone; seven-sixteenths of an inch in its vertical diameter, and of doughy consistence. It was attached by a sort of pedicle, which was found to extend into the right internal auditory canal. Its consistence was considerably greater than the larger tumor, on the left side, and the eighth nerve was more intimately united to it. As its presence was not known until after the removal of the brain and the division of the nerves was made, it is not known positively what relation it sustained to the eighth nerve; but, apparently, the nerve-trunk ran under it to reach the internal auditory meatus. The tumor had, as on the other side, considerably enlarged the porus acusticus internus. The bone was not uncovered, the dura mater being still adherent, but thinned. The right eighth nerve, from its origin, seemed of normal size and consistence.

Microscopical Examination of Left Cochlea.—The tumor on the left petrous bone, as already described in the post-mortem record, had pressed flat the nerves entering the porus acusticus on this side. The new growth had, by pressure, enlarged the opening and forced itself into it for some distance, making the internal auditory canal funnel-shaped. There was no evidence that the growth extended in the nerve-trunk itself, or that it had reached the fundus of the canal. The canal was occupied by an increase of connective-tissue substance toward the base of the cochlea. The walls of the internal auditory canal were covered by a thin periosteum; the bone was everywhere covered, and presented no roughness nor erosion.

The shape of the modiolus was normal. The spaces in its substance, which normally are occupied by divisions of the cochlear nerves, showed no trace of nerve-fibrillæ or ganglia. At one point was seen some exceedingly delicate fibrous tissue arranged in a regular, wavy manner. Many of the spaces contained granular and fatty detritus, showing in its midst a few fine fibres, by which the material was held in place in connection with the walls of the spaces; these fibres took somewhat the form of a network. Others of the spaces were nearly free of contents, showing sometimes a scant fibrous network; sometimes the space was crossed by a delicate bony trabecula. A number of vascular lumina were here visible, often recognizable by their corpuscular contents; their size was small and their number not great.

The lamina spiralis ossea was normal in shape; the space between the lamellæ of bone contained no trace of nervous tissue, but was occupied by a very fine fibrous material, containing in it much less granular matter than similar tissue in the spaces of the modiolus, with which it was continuous.

The membrana basilaris was not sufficiently well preserved in any of the sections to admit of a particular description. The pieces of it that were examined, however, showed no marked changes. Nothing was seen of Corti's organ. The ligamentum spirale externum of Henle was normal in appearance. The lining cubical epithelium of both scalæ was very distinct, and presented a smooth, even surface. The bone at all parts presented, microscopically, perfectly normal conditions.

Microscopic Examination of Right Cochlea.—The tumor had grown deeply into the internal auditory meatus, which was dilated from atrophy of its wall by pressure. This atrophy extended markedly toward the base of the cochlea, reaching close up to or into the modiolus, where parts of the tumor in mass could be seen. In consequence, the bony parts between the scalæ and the fundus of the internal auditory canal were rendered thin.

The modiolus did not present the characteristic form, and differed in shape also from that shown in similar sections taken from the opposite cochlea. The alteration was more noticeable in parts nearer the summit, and was partly due to new material extending within the scalæ, and partly to a change within the bone itself; whether this was from an extension of the tumor, or from other changes in the bone, was not determined.

The bloodvessels were not a conspicuous feature in the modiolus; they certainly were not increased in number, nor were their lumina exaggerated. A number of them contained corpuscular elements. The bone-tissue at this portion was normal in appearance. The ganglionic spaces in the modiolus presented a markedly different picture from those on the opposite side; they contained a granular, amorphous material or cell-structure. No appearance of new fibres, nor indeed of fibrous material, was made out. Near the junction of the lamina spiralis ossea with the modiolus these spaces became larger, and the cellular nature of their contents was more distinctly to be seen. In some sections this cellular material seemed directly continuous with the material deposited within the scalæ.

The lamina spiralis ossea presented about the same appearance in all the sections, and was unchanged in form. The space between the bony lamellæ of the lamina spiralis showed no nervous structure, but contained granular material quite dense in character. The demarcation between the osseous lamellæ and the space itself was very distinct; the lamellæ themselves, except in their rigidity, gave no characteristic bony appearance. They took the staining of chromic acid quite deeply, whilst the granular material between was nearly cleared of color by washing and soaking in oil of cloves. In one or two places only, in all of the sections, was seen, between the lamellæ, a trace of fibrous tissue.

At the habenula perforata there were no nerve-fibres to be recognized. The *membrana basilaris*, in sections equally delicate with those taken from the opposite side, was much better preserved in the right cochlea than in the left. It showed sometimes in cross-section, sometimes in mass, giving a profile view of some extent of its surface; sometimes it was in connection with the ligamentum spirale, sometimes it was torn loose from this connection, and was lying free in the scala; again, it was crumpled up by the separation of the ligamentum spirale from the outer bony wall. In none of the sections did it appear to have any of Corti's organ in relation with it. In some of the specimens there seemed to be a thickening or a growth developed upon this membrane, as will be spoken of below. Corti's organ, except in one doubtful instance, was not to be seen, even in a fragmentary condition, in the preparations. I do not mean to imply that Corti's organ was destroyed or wasted, but simply state the fact that, in carefully treated specimens, no certain trace of it was discovered.

The membrane of Reissner was, of course, not preserved; only its ends of attachment at the outer wall and at the lamina ossea were represented by a trace of tissue.

The membrana tectoria was seen in a more or less fragmentary condition in all the specimens, attached to the extremity of the labium vestibulare, while the other end of it was not in connection with any tissue, but floated freely in the ductus cochlearis. In the sulcus spiralis was seen in some specimens a small collection of material, mostly of a granular nature, although sometimes it presented distinct cell-elements, not unlike in appearance those seen at other parts, whose origin from the new growth was undoubted.

Concerning the scalæ, it was noted that, when the cochlea was first laid open, a material was seen by the naked eye within them, placed at the junction of the lamina spiralis ossea with the modiolus, and both above and below the lamina, *i. e.*, in both the scala vestibuli and the scala tympani. With the microscope, this material was very conspicuous in all of the sections examined, and it was more abundant in the scala tympani. In places there was seen a connection or continuity between the new growth within the spaces of the modiolus and that of the scalæ. This material showed an extension of itself along the fibrous covering of the lamina spiralis ossea. In no instance did it extend, however, to the membrana basilaris, although in some specimens there could be seen an unevenness of the epithelial lining of the scalæ.

At the outer wall of the cochlea, especially at the ligamentum spirale and its stria vascularis, there was more material of nearly the same appearance; it was never seen in masses, projecting into the cleared spaces, but showed as a roughness and irregularity of the lining membrane. This change was chiefly in the ductus cochlearis on its outer wall. The change was not limited merely to the surface, but showed itself in the deeper parts, and the condition was more apparent in instances where the ligamentum spirale had been dragged and separated from the outer bony wall. The effect of this new material was to give an appearance of greater thickness to the ligamentum spirale, especially near its union with the membrana basilaris. In some specimens it appeared as though this material extended along the membrana basilaris; in no instance was it seen in continuity with similar changes on the lamina spiralis ossea, but was coexistent with such a condition. As far as the membrana basilaris itself was concerned, the change appeared limited to the upper (ductus cochlearis) surface; although the limitation of the material to this surface could not be affirmed positively in cross-sections, other specimens seen in profile from below showed no material to be present on the under (scala tympani) surface. No good nor distinct profile view of the floor of the ductus cochlearis was obtained.

No examination with gold solution was made for the presence of nerve-fibres, as this test, as is universally conceded, is valueless, except when carried out in perfectly fresh tissues. Innumerable pigment-masses were seen at the periphery of the sections, and in the modiolus, such as have been seen on other occasions in bone treated with chromic solution and acid for the purpose of decalcification. May not this be the origin of the "brownish pigment, mostly deposited in multipolar cells," described by Boettcher as occurring in a similar position?

This case, as well as the one about to be given, will furnish many points of guidance in establishing a differential diagnosis between Ménière's disease, or labyrinthine vertigo, and the vertigo associated with permanent alteration in the gait, very often observed in cases of cerebral tumor.

February 1, 1876, James L., aged 35, laborer, Irishman, was admitted to the wards of Prof. J. M. Da Costa, in the Pennsylvania Hospital. The patient admits having had a chancroid ten years previous, but denies all secondary symptoms, and none can be found. Six years previous to admission to the wards he had suffered from malarial fever, for which he had taken large doses of quinia without poisonous effects, but he had been salivated. His health had been good up to seven weeks before entering the hospital, when he took cold from exposure, had a severe coryza, and in less than a week he had noticed buzzing in his ears, vertigo, staggering in his gait, but *no alteration in hearing.* When he would sit or lie down, his vertiginous symptoms would vanish. Headache was complained of, and nausea and vomiting had occurred at times.

On admission to the hospital, it was found that there was a depression in the skull at the junction of the sagittal and coronal sutures, but no other evidence of *violence* to the head; he could give no account of the origin of the depression in the skull.

Pupils were normal; tongue extended straight; voice high-pitched; patient cheerful; the hearing was found to be for the watch, on the right side, $\frac{12 \text{ in.}}{4 \text{ ft.}}$; on the left side, $\frac{5 \text{ in.}}{4 \text{ ft.}}$. There was decided loss of sensation and power on the left side, in arm and leg. Electro-muscular contractility was not impaired; slight loss of coördination; he could walk with eyes shut as well as open; stands poorly on one leg, but picks up small objects well.

He walks with his legs far apart, tending to the left side, towards which side he easily falls. Stands with legs widely separated, for when erect he soon leans towards the left; the least push would then throw him towards the left side, whereas he was quite firm when pushed in any other direction. Dimness of vision had been noted by patient; the ophthalmic examination made by Dr. W. F. Norris showed slight haziness, and striation of the retina in each eye.

The urine was high-colored and slightly turbid; sp. gr. 1021; acid; no albumen; no sugar; there were traces of urates. Occasionally severe pain in back of head, relieved by bromide of potassium; vertigo felt only in the upright posture; feels a subjective, not an objective, uncertainty in walking. No murmur in temporal or mastoid region. Such were the general notes on the ward-book.

Aural Notes.—Both drum-membranes were normal in lustre, color, and tenuity; not the slightest congestion in them anywhere.

Inclination of membranes nearly normal; left (deafer side) a little more retracted than right. The former, therefore, shows less of a pyramid of light than the latter. Under the pneumatic speculum the left moves more readily than the right membrane. Hearing for watch, L. = $\frac{1}{60}$; R. = $\frac{1}{5}$. Speech is heard relatively much better than the watch. Patient said he heard a vibrating tuning-fork placed on his vertex in both ears. Eustachian tubes perfectly pervious, as shown by the Eustachian catheter. Hearing was not altered by inflation of tympanum.

Unusually severe sneezing[1] *was caused by the introduction of the catheter;* he thought his ears buzzed a little more after examination. Vertigo and gait were in no way changed by manipulation and examination. He says he is dizzy whenever, and only whenever he attempts to walk, and relief is always obtained by sitting down.

There was considerable nasopharyngeal catarrh, but the Eustachian tubes were pervious, as stated. There was no evidence of accumulation of mucus in the tympanum, and the external auditory canal was entirely normal. Nothing, therefore, was found in either of these parts of the ear to account for the peculiar symptoms in this case. If the man's statement be true, that his hardness of hearing, peculiar vertigo, and altered gait came on at the same time, this would look like a case of aural vertigo, but every well-marked case of vertigo from aural irritation is *paroxysmal* as to the onset of dizziness, reeling, falling, etc. Some tinnitus, and usually considerable alteration in hearing remain, but the gait is never *permanently* changed.

Pathological Changes.—In a case recorded by Moos,[2] the post-mortem examination revealed a tumor of the left auditory nerve, which had caused compression of the pons cerebelli, and of the left oculo-motor, the fifth, and the facial nerves; there was also gray degeneration of the spinal cord. The condition of the organ of Corti was one of fatty change, and partial destruction. In the case of Cruveilhier referred to, there was found under the tentorium cerebelli on the left side, a hard nodulated tumor, which pressed upon the left half of the pons, the medulla, the peduncles of the cerebellum, and upon the cerebellum itself. The tumor hung by a stout pedicle over the posterior surface of the petrous bone. The seventh nerve was destroyed at the porus acusticus internus.

Fibro-sarcoma.—Dr. Boettcher,[3] of Dorpat, writes of *fibro-sarcoma* of the auditory nerve as of no uncommon occurrence.

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[1] Great susceptibility to sneezing has been observed in cases of tumor of the brain involving the auditory nerve.

[2] Archives of Oph. and Otol., vol. iv. p. 484.

[3] On Changes in the Retina and Labyrinth in a case of Fibro-sarcoma of the Auditory Nerve. Archives of Oph. and Otol., vol. iii. pp. 134–171, 1873.

But he believes, that the microscopic changes in the labyrinth in such cases have usually escaped attention. Fortunately for otology, the article on the case referred to is offered by its distinguished writer as the beginning of a pathological histology of the cochlea.

In the case of a young woman, 21 years old, who died in consequence of the cerebral tumor, the morbid growth was found connected with the common trunk of the facial and the auditory nerves. The latter appeared like a white cord, 2 cm. long, and 1 mm. thick, showing, under the microscope, medullary nerve-fibres in all its fasciculi, but the medullary sheath was nowhere complete.

The great denudation of entire fasciculi of axis-cylinders, noted in this case, was considered very extraordinary. All the fibres were colored by chloride of gold, intensely violet. Fatty degeneration was not discoverable in the specimen mounted in alcohol. Part of the tumor extended into the porus acusticus internus. This canal was found dilated in all directions by the morbid growth. This was deemed simply the result of atrophy from pressure. At the bottom of the internal auditory canal, where the tumor was found in contact with the base of the cochlea, the growth bulged toward the modiolus.

Not a trace of nervous elements remained in the modiolus. An absence of the nerve-fibres was also demonstrable in the spiral canal of the modiolus. The lacunæ once occupied by the spiral ganglion were empty.

Changes in the Vestibule and Semicircular Canals.—"Here the epithelium and connective tissue-envelope of the sacculi, and membranous canals were well preserved; large and numerous vessels were observed in the envelope. The macula and the cristæ acusticæ were unaltered in form, but no nervous fibres were seen to enter these structures."

The facial nerve was present from the angle of, and filled the bony canal. The ganglion geniculatum was found to be atrophied. There was facial paralysis on the corresponding side. The tumor was classed by Dr. Boettcher among the fibro-sarcomata.

Glioma.—Brückner[1] has described a cerebral tumor, which occurred in his wife, in whom the suspected cause was a fall on the back of her head on the ice, in her thirteenth year. The first symptoms of the disease were noted about three years later, in the form of uncertainty in the use of her upper and lower limbs. Four years before her death, which occurred when she was twenty-eight years old, a diminution of hearing upon the left side was accidentally noticed, with giddiness and catarrh of the middle ear; and, finally, complete deafness. A singular phenomenon in this case was that, three or four months before death, a whirring, like the placental murmur, could be heard by applying the ear directly to the patient's left temple; once, very feebly on the right temple; the sound ceased to be heard by herself or others after she had taken large doses of iodide of potassium. The left auditory nerve was found to be entirely obliterated, and in its place there was a large glioma.

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[1] Berliner Klin. Wochenschr., No. 29, 1867.

The Labyrinth in Ileo-typhus.—By post-mortem examination, Moos[1] found in the labyrinth of a soldier who had died of ileotyphus or typhoid fever, a large quantity of lymphoid corpuscles on the lamina spiralis membranacea, on the sacculi and the ampullæ. Some of these had undergone fatty degeneration. They were most numerous in the region of the point of entrance of the cochlear branch of the auditory nerve, into the labyrinth.

Fatty metamorphosis of the organ of Corti, closely resembling that found in sarcoma of the auditory nerve, may also be the result of hemorrhages into the cochlea, as shown by Moos.[2]

Amyloid degeneration of the auditory nerve has been fully described by Förster[3] and Voltolini,[4] and its occurrence corroborated by Lucæ and Politzer. It appears to be of common occurrence, as stated by Gruber.

Hallucinations of Hearing in the Insane.—Hallucinations of hearing are common in the insane. They are very often not dependent upon any aural disease; though in many instances they seem to have been induced by a disease in the ear. In some instances, after the removal of a plug of cerumen or other morbid cause of the hallucinations, the latter have been diminished, but not entirely removed. They have been noted in women afflicted with nymphomania. In such, the hallucination has been the supposed hearing of a man's voice, which, as Dr. O. D. Pomeroy[5] has observed, indicates rather a disease of the nervous system than of the ear. Still, whenever insane patients complain of subjective hearing, their ears should be examined, for a removal of the aural irritation, if one should exist, may relieve, if it does not entirely banish the hallucinations.

Moos[6] found an enlargement of the bulb of the jugular vein in the right petrous bone of an insane man, who had suffered with the most intense and distressing noises in the ear, and to escape which he finally committed suicide.

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[1] Ueber die Anatomischen Veränderungen des Häutigen Ohrlabyrinths bei Ileo-Typhus. Verhandl. d. Naturwiss. Med. Vereins zu Heidelberg, v. 199; also M. f. O., No. 2, 1872.

[2] Archives of Oph. and Otol., vol. iv. pp. 497–502, 1875.

[3] Atlas of Pathological Anatomy, p. 86, 1854.

[4] Virchow's Archiv, vol. 22, p. 114, 1861.

[5] Hallucinations of Hearing in the Insane, Transactions American Otol. Soc., vol. i. p. 184, 1871.

[6] Archives of Oph. and Otol., vol. iv. pp. 479–482, 1875.

It was supposed that when blood passed from the lateral sinus into the enlarged bulb of the jugular vein, vortices must have been formed in the current, and in consequence thereof a blood murmur must have been produced, which on account of its nearness to the labyrinth must have been heard as a loud subjective noise. In this account, allusion is made to the theories of Oppolzer, Friedreich, and Boudet. They explain the tinnitus of chlorotic patients as a subjective perception of the *bruit de diable*, because it disappears usually on compression of the carotid. Friedreich has not found this rule invariable.

I have known an insane woman to be distressed and made worse by the imagined hearing of an infant's cry. As she could not stop the imagined cry of pain, that of her own child, whose death had caused the insanity, the brain symptoms became markedly worse. The ear was not examined in this case.

An insane man, with normal ears, once or twice presented himself to me for treatment to gain relief from sounds of a peculiar kind, "spirit voices," which he seemed to hear in the air above his head. These sounds were not always disagreeable to him, but were annoying by their long continuance, and by their preventing sleep. The ears were carefully examined in this case, but nothing whatever abnormal was found in them. The tinnitus of the insane is referred either to the interior of the head or to a point outside, but not remote. It might be termed cerebral and not aural tinnitus.

Nervous Deafness.—Strictly nervous deafness must be regarded as among the greatest rarities. Among the peculiar nervous symptoms which sometimes attend acute articular rheumatism, may be found a form of acute deafness, which might be called nervous. At the same time hysterical symptoms may manifest themselves.

Dr. S. Weir Mitchell has called my attention to what he terms hysterical deafness. In the case of a young woman he observed a deafness, which would apparently come and go during conversation. At other times, the patient would fail to hear under circumstances in which she had but a short time before appeared to hear well. I have never observed such a case, but I doubt not that such should be classed under hysterical phenomena.

Moos[1] observed a case of intracranial disease after acute rheumatism, with peculiar nervous phenomena, combined with complete deafness for noises, musical tones, and speech. The patient was communicated with by writing, for several weeks. Under the use of the constant electric current, the patient entirely recovered.

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[1] Archives of Oph. and Otol., vol. i. p. 464.

When it is remembered that there is a close connection between acute articular rheumatism, chorea,[1] and meningitis, it can be understood how the hearing might be either temporarily or permanently affected by the rheumatic poison.

Total deafness may be the result of a fall brought on by dizziness from causes other than aural. This fact must be carefully borne in mind in estimating the part the ear may have had in the production of the primary disease, as is shown in a case given by Moos,[2] as follows: A soldier suddenly fainted and fell, without any previous warning. Upon the return of consciousness, he was found to be entirely deaf to all sounds. Subjective noises were noticed at first, but they gradually ceased. It was believed that, in consequence of the fall, an extravasation of blood took place at the origin of both auditory nerves; in no other way could the total and sudden deafness be accounted for. Fracture of the bone would in all probability have produced death. The precise seat of the extravasation was supposed to have been in the medulla oblongata, at the point of origin of the deep root of the auditory nerve.

If a repeatedly applied galvanic current of such intensity as will cause twitching of the muscles of the face and the extremities, fail to produce sensations of hearing, we may infer the existence of complete paralysis of the auditory nerve, and form an unfavorable prognosis.

The Effects of Quinine upon the Ear.—The question is often asked, Does quinine cause ear-disease—Does it make one permanently deaf? And the answer, so far as I am able to give it, is always in the negative. I say this with all reserve, and with the full knowledge that many high authorities[3] have taken an opposite view, and have, as they believe, adduced proof of its correctness. Wherever quinine has been supposed to be a cause of deafness, usually it can be shown that the disease for which the drug has been given is the underlying cause of the failure in hearing. It is most positively known that malarial diseases—chills and fever—for which large doses of quinine are usually given, are frequently followed by hardness of hearing and deafness, whether quinine be given or not. But yet malarial disease often runs its most virulent course, and quinine is also given in large doses, without the production of deafness.

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[1] Germain See; De la Chorée, Paris, 1850.

[2] Archives of Oph. and Otol., vol. ii. pp. 199–203, 1871.

[3] Dr. Roosa, Trans. Amer. Otol. Soc., vol. i. p. 276; also vol. ii. p. 93; also M. Mélier, Mémoires de l'Académie Royale de Médicine, p. 722, quoted by Drs. Roosa and Hammond.

A great many patients think they are deaf in consequence of taking quinine; but in all such cases which I have observed, there was most evident cause for the deafness, in catarrhal disease of the nasopharynx and throat, which antedated the administration of quinine. In many cases, the diseases for which the quinine had been given, as puerperal maladies, continued fevers, chest-affections, etc., were an amply sufficient cause of deafness, and not the taking of the drug in question.

It is admitted that quinine will cause ringing in the head and ears as well as temporary hardness of hearing, probably by congestion of the middle ear. But were quinine injurious to the ear, its ill-effects could be plainly seen when given to those affected with aural disease. On the contrary, a partially deaf person may be made temporarily deafer, but when the quinine is no longer taken, the hearing returns to its relatively normal point. Furthermore, some kinds of tinnitus aurium, viz., from anæmia and debility, are stopped by taking quinine. Of course, poisonous doses of quinine, like any other morbific element introduced into the blood, might have a bad effect on the nerve of hearing, and on the sound-conducting parts too. But, so far as my experience goes, all necessary doses of this useful drug can be given in any case with impunity, whether the ears are affected or not.

It would appear that sometimes *congestion* of the external ear occurs as the result of the administration of large doses of this drug.[1]

H. N. Spencer[2] has observed that quinine congests the membrana tympani in a few minutes. But he finds no evidence that the hearing is permanently affected by the drug. Kirchner,[3] however, claims that quinine may produce permanent changes in the ear by vaso-motor disturbances, the congestion apparently beginning in the tympanic cavity, and extending to the labyrinth. Weber-Liel[4] maintains that both salicylic acid and quinine produce hardness of hearing, that induced by the former being greater and lasting longer than that caused by quinine. It is claimed that both drugs lower the temperature of the external auditory canal.

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[1] Roosa, Transactions American Otolog. Soc., vol. ii. p. 93.

[2] American Journal of Otology, vol. iii. 168, 1881.

[3] Berliner Klin. Wochenschrift, 49, 1881.

[4] Monatsschrift für Ohrenheilkunde, No. 1, 1882.

SECTION VII.

DEAF-MUTES AND PARTIALLY DEAF CHILDREN.

CHAPTER I.

METHODS OF RELIEF AND EDUCATION.

DEAF-DUMBNESS may be either congenital or acquired. In some instances, the two forms may be united, as shown by Moos.[1]

Recent investigations by Luys,[2] into the structure of the central nervous system, have led him to locate the sense of hearing in the posterior lobes of the cerebrum, in which theory he believes himself further strengthened by the condition of the brain in two deaf-mutes.

In one, an intelligent man, 72 years old, who had died of pneumonia, some of the inner convolutions of the posterior lobes of the cerebrum were atrophied, yellowish, and at points œdematous; on the right side these changes were more marked than on the left side. The white fibres of the brain, which connected these parts with the optic thalami, the point deemed by Luys the centralizing area of all outward nervous impressions, were traversed by growths of connective tissue, and had undergone amyloid degeneration. At the optic thalami only, the posterior nuclei were infiltrated by serum, soft, and amyloid. The gray substance about the aquæduct of Sylvius presented a similar condition. The remainder of the brain was normal, but the acoustic nerve was atrophied at spots.

In another mute, 14 years old, a similar condition was found. Dr. Kuhn states that Hunter[3] has also described quite extensive changes in the optic thalami in a case of absolute deafness.

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[1] Archives of Oph. and Otol., vol. ii. p. 138, 1871.

[2] Contributions à l'étude de lésions intracérébrales de la surdi-mutité, Ann. des maladies de l'oreille, 1875, pp. 313–322. See A. f. O., Bd. xi. S. 179; abstract by Kuhn.

[3] Transactions of Medico-Chirurg. Soc., London, 1825.

The congenital form of deaf-dumbness has generally been considered as the commoner occurrence. In comparatively few instances its existence has been proven by post-mortem examination to have been due to malformation of the internal ear or of parts of the brain. Knowledge as to its true nature and cause would be greatly enhanced by more thorough records, in deaf and dumb institutions, of the condition of the ear during life and a complete description of its state, as revealed by post-mortem investigation.

Beard and Roosa[1] placed the average of congenital deaf-muteness at about sixty-one per cent. of all cases of mutes; Wilde placed it at fifty per cent.

By a reference to the reports of the last three years, of the Pennsylvania Institution for the Deaf and Dumb, Philadelphia, it will be found that one hundred and thirty-seven children were admitted within that time, who lost their hearing from fever and other causes, and had in consequence become dumb. They constituted *two-thirds* of the entire number of admissions, thus showing that, in this institution at least, *congenital* deaf-muteness is considerably less frequent than the acquired form.

It is held by von Troeltsch that an hereditary tendency to deaf-dumbness exists in some families. Within a very short time I have seen a family in which four children were deaf mutes. But it appears from the investigations of modern times that the *acquired* form of deaf-muteness is by far more common than was once supposed.

In many instances the history of a case points to a destructive disease of the sound-conducting parts in the tympanum and also in the labyrinth, at a very early period of extra-uterine life. But even in these lamentable cases, to state that the sufferer came into the world endowed with the power to hear, is often a grain of comfort to parents who cannot bear to regard a child as congenitally defective.

Every physician may be called upon to decide whether a child is deaf and dumb, and if it be, to suggest, if not a cure for the deafness, at least a plan for the proper education of the little patient.

In very young children it cannot be readily decided whether total deafness exists or not. But whether a child is totally deaf or not, it may be too deaf to learn to talk by hearing others speak. It is not unusual to find pupils in deaf and dumb institutions who can hear loud sounds, and even the human voice when shouted into their ears.

Without deciding, therefore, that the child is entirely devoid of hearing, a physician may find, on examination, that it is too deaf to learn to talk in the ordinary way, in which case he should advise its parents to arrange for its proper education in another manner.

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[1] Op. cit., p. 515.

Advice is rarely sought respecting the aural condition of a child until, having come to an age when most children begin to use words intelligently, it arouses suspicion as to its peculiar defect, by showing no evidence of learning to talk.

It may be stated by the parents that they believe the child was, at one time, able to talk, because it has spoken such words as "mama or papa;" but the mere utterance of these elementary sounds of speech, which may occur entirely involuntarily in extremely young infants, is no evidence that the child hears. If there is reason to believe that the fears of the parents respecting the deficiency in the child are well grounded, a thorough examination of the ear should be made. If nothing abnormal can be discovered in the external or middle ear by inspection, or by inflation, and if the child has reached an age when it ought to talk, it may be concluded that it is too deaf to learn to talk by hearing others, and that, in all probability, its deafness cannot be relieved. If, however, on inspection an obstruction or deficiency in the sound-conducting parts is found, or if a suppuration exists in the ear, all such interferences to hearing should be combated in the ways already named in a previous part of this work. Without doubt some cases of deaf-muteness might be prevented by an early treatment of the local symptoms.

There is every reason to believe that very young children may be the subjects of chronic aural catarrh, which comes on insidiously, producing in them progressive hardness of hearing. While the same grade of hardness of hearing which has resulted in them would not seriously impede an adult who had already learned to talk, a child thus affected is too deaf to learn to talk by hearing others speak. I have found that mute children, in whom the membrana tympani showed signs of chronic aural catarrh, at the age of four and a half years, could hear the voice probably well enough to be taught to speak, when addressed by means of an ear-trumpet, if it were possible for any one in their family to undertake so laborious a method of instructing them.

Beyond combating a disease already firmly seated in the sound-conducting parts of the ear of a deaf-mute, the surgeon can do nothing.

If the changes in these parts have not been of a deeply organic nature, the hearing may be partially restored. But if these changes have been of a structural nature, or have extended to the internal ear, litttle, if any, benefit to hearing can be hoped for. The only plea for treating a suppurative disease, which is not uncommon in deaf-mutes, would be to prevent the *fatal* results of neglected otorrhœa.

While it is by no means the province of this book to describe or advocate any particular method of instructing deaf-mutes, a word may be said respecting the methods which are usually employed.

In all civilized communities there are provisions for the proper corporeal, moral, and intellectual training of the deaf and dumb. Deaf-mutes naturally communicate with one another by means of a sign-language, which, in most respects, is common to all nations. This method, scientifically elaborated, is termed dactylology or finger-talking. Until within a few years it has been the only mode of instructing deaf-mutes in England and the United States.

The German system of educating mutes by teaching them to understand and use language, by observing and imitating the articulate speech of others, in which method the pupils are most positively forbidden to use the sign-language, has been employed for a long time in most of the countries of Continental Europe. An accurate and succinct account of this so-called German method may be found in a most interesting *brochure* on the subject, by Mr. W. B. Dalby.[1]

Instances of mutes learning to understand what was said to them, by watching the lips of the speaker, are on record from the beginning of the eighth century, when John De Beverley, Archbishop of York, thus instructed an adult mute in the Christian religion, to the middle of the seventeenth century, when the book of John Bulwer induced John Wallis, of the University of Oxford, and William Holden, Canon of Ely and St. Paul's, to devote themselves to the education of the deaf and dumb by means of lip-reading.

It has also been practised in Spain and Italy between these two periods above alluded to, England, however, appearing to have been the pioneer in this mode of instruction, though among the last to give it an extended trial.

Heiniche, of Germany, in the middle of the eighteenth century, seems to have been the next notable advocate of instructing deaf-mutes by lip-reading and articulation. It is now universally employed in that country.

In order to accomplish education by this means, the child must possess ordinary intelligence, normal vocal organs, and it must begin its studies in this direction at not later than seven years of age. The average length of time which must be given this course of education before the pupil can understand and communicate with any one he may meet, is about eight years.

But great attainments are thus made. It is a well-known fact that English mutes thus instructed have learned to talk not only their own language, but French and German, and have become brilliant ornaments to society.

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[1] "Education of the Deaf and Dumb by means of Lip-reading and Articulation." By W. B. Dalby, F.R.C.S., M.D. (Cantab.), London, 1872.

In Vienna, I have frequently conversed in their own language with German deaf-mutes who had attained such accuracy of observation of the lips of the speaker that they immediately perceived my foreign accent.

Bell's System of Visible Speech.—There is another means of teaching deaf-mutes articulation, and that is by the system of visible speech, or phonetic writing, of A. Melville Bell.

It is based on the physiological action and position of the vocal organs during speech, and is practically an alphabet of sounds, in which the symbols inform the child how to place its lips, tongue, and palate, and thus produce a vocal sound. It was successfully employed in England in 1869, since which time it has been introduced in several institutions in this country.

Lip-reading and visible speech may be of great value in the education of children who have become deaf after having learned to talk in the first four or five years of their life. Children of this age, who become entirely deaf in consequence of scarlatina, cerebro-spinal meningitis, or of any disease, will often voluntarily cease to talk, and thus, forgetting how to use speech, become mutes. I recall the case of an intelligent boy, six years old, who, becoming entirely deaf after cerebro-spinal meningitis, showed the greatest reluctance to talk, and relapsed at once into making signs, with the result of becoming mute. No matter how deaf a child may have become after it has learned to talk, it should be coerced to continue the use of speech, and *discouraged* in the use of signs. His conception of what speech is and his ability to use it are invaluable aids in his further education by means of lip-reading and articulation, or by visible speech.

Partially Deaf Children.—There is a large class of children, who are by no means deaf-mutes, yet who hear so badly as to be under constant disadvantages at ordinary schools. Such children, on account of their poor hearing, are often imposed upon, both by their companions and their instructors; the former deceiving them, the latter misunderstanding them, and consequently losing patience with them. Do as they may, such pupils must fall behind.

It is not desirable for many reasons that children who have learned to talk, but who have become quite dull of hearing, should be isolated into separate classes; it is much better they should continue their studies with those among whom their lives are to be spent. But allowance should be made for their defective hearing. This can only be accomplished by first ascertaining it. Many a child is hard of hearing without knowing its defect; it is, therefore, the place of its elders to find out and determine the amount of its deficient hearing.

That some special provision must be made for such children is fully justified by the statistics compiled by Dr. C. J. Blake, who has shown that out of 8715 cases of ear-disease, accompanied by impairment of hearing, 2175, or 25 per cent., were children under fourteen years of age, all of them pupils in the public schools.

In order that proper allowance be made for their defective hearing, he has suggested that a careful examination "should be made in each case, to determine the degree of deafness as tested by the distance at which the voice of the teacher can be heard in ordinary conversation tone, and again by the pronunciation of consonant tones." These tests could be made by the teacher, and the following directions for making them are given: The teacher should always occupy, in testing the different cases, the same position, preferably the rostrum or seat usually occupied by him in school-hours. He should speak in the same tone of voice used in the school-room exercises. The child to be tested should be placed in front of the teacher, and at the extreme limit of the farthest line of seats, and gradually advanced toward the teacher at certain intervals, the tests being repeated until a point is reached at which the child can hear distinctly. This point should determine the place the child should occupy in the school-room. The ears should be tested separately, the ear to be tested being turned toward the teacher, while the other is artificially closed. The child should be required to repeat distinctly the words as he hears them. The use of the voice in making tests of this kind is preferable to the use of watch, musical instruments, and the like, as being more applicable to the child's needs. The tests should be repeated when the child passes from one room to another, as the degree of deafness often varies at different ages. The examination of pupils by a medical expert is recommended as preferable, since an opinion of the nature of the aural disease and the mode of treatment could thereby be afforded the pupil. Dr. Blake strongly recommended the establishment of a medical supervisor of schools; the post to be occupied by a competent physician, who had made the matter of school hygiene a study, and his whole time to be devoted to the duties of his position.

Such a careful and scientific examination would reveal that some of the children are suffering from a disease of the ear, entirely amenable to treatment if given at that time. They would, by thus being taken care of, not only regain hearing, and make more rapid advances in their studies, but they would often be enabled to get rid of a disease which would otherwise gradually grow worse, because unrecognized, and finally, becoming irremediable, render them permanently deaf. There is no greater fallacy in hygiene than that a child "will outgrow deafness." Dr. Samuel Sexton[1] makes the very important suggestion that teachers do not enjoy greater immunity from hardness of hearing than others in the same social position, and that, therefore, those preparing or offering themselves as teachers, should be examined regarding their hearing-power. This might be very satisfactorily tested if the examinations for admission to the ranks of teachers were oral instead of written.

Ear-trumpets.—It has been proposed that the hopelessly hard of hearing use ear-trumpets. Such instruments are of most service when the defective hearing is due to a chronic catarrhal process in the middle ear, in which the ossicles and the membrana tympani are present. By a concentration of sound upon the conducting parts, the latter are in many instances made to perform their function better. If, however, the nerve is diseased, the concentration of sound by means of ear-trumpets will not be of much aid.

It has also been observed that, in cases of chronic suppuration with perforation and destruction of the drum-head, the use of the ear-trumpet is more apt to produce confusion and dizziness, than better hearing. No one form of ear-trumpet can be considered the best; each patient must be tried by a series of instruments, until one is found which proves of service to him.

It may be said most positively that all small, and so-called "invisible" ear-trumpets, or instruments to assist the hearing, no matter under what name they are vended, are *useless*, because they neither concentrate more sound upon the drum-head, nor increase the resonance of the external ear. In every instance all such instruments, which lie in the auditory canal, interfere with what little hearing may still exist. There is one exception, viz., in cases of hardnes of hearing due to a collapse of the cartilaginous auditory canal, if such cases exist. Here, relief may be gained by holding the walls of the meatus apart by means of a small tube of some kind. Although I have never seen such a case, I am able to conceive that some instances of impaired hearing in old people may be due to such causes, after the loss of teeth, and the consequent alteration in the position of the under jaw, and the encroachment of its condyle upon the tissues of the external meatus of the ear. I have heard of a case of hardness of hearing which was relieved by wearing a complete set of artificial teeth. This, of course, would render the position of the under jaw normal, and thus relieve what has been called collapse of the auditory canal.

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[1] Circular No. 5, 1881, Bureau of Education, Washington, D. C.

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